THE JOURNAL and THE BULLETIN

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FEBRUARY 15, 1942

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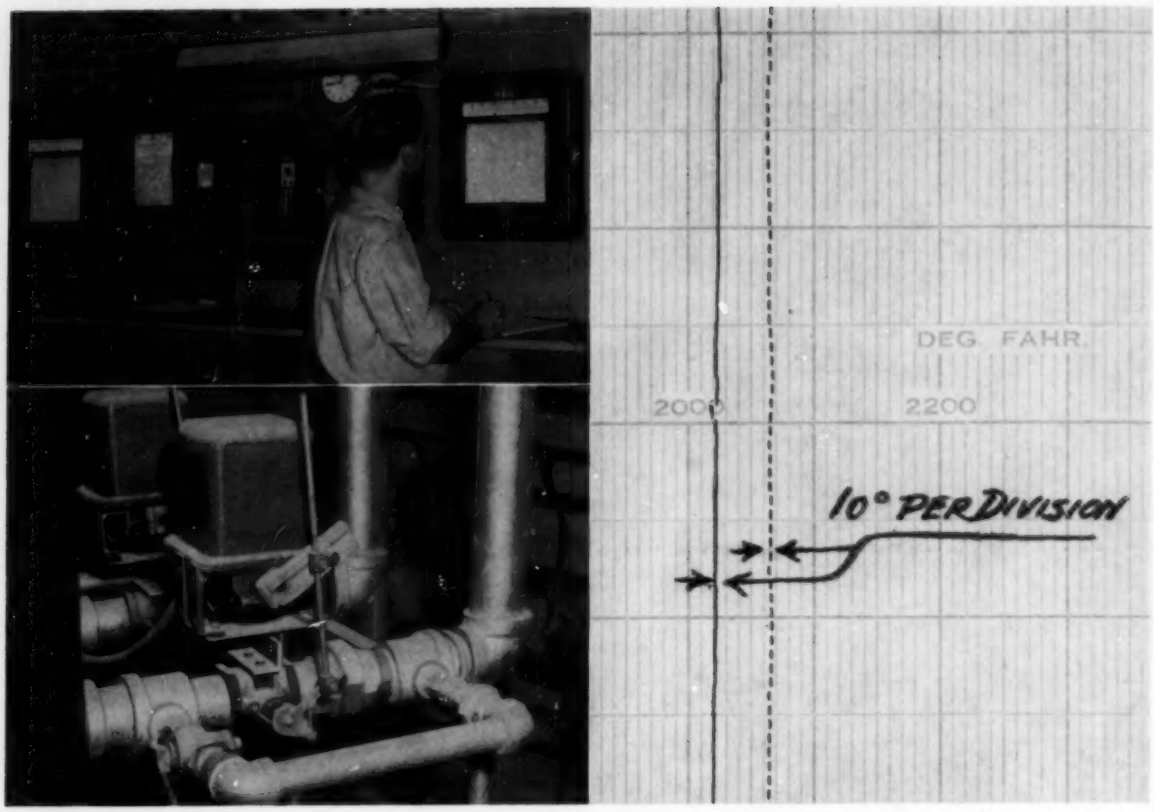

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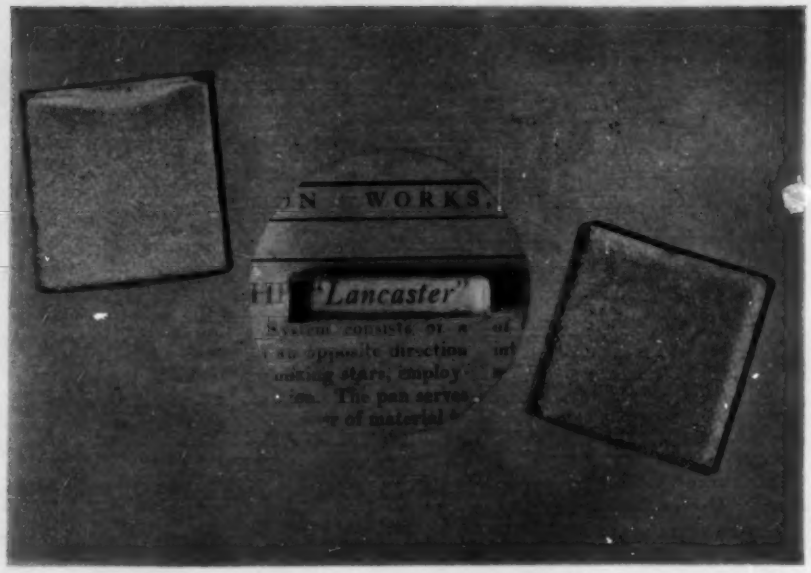

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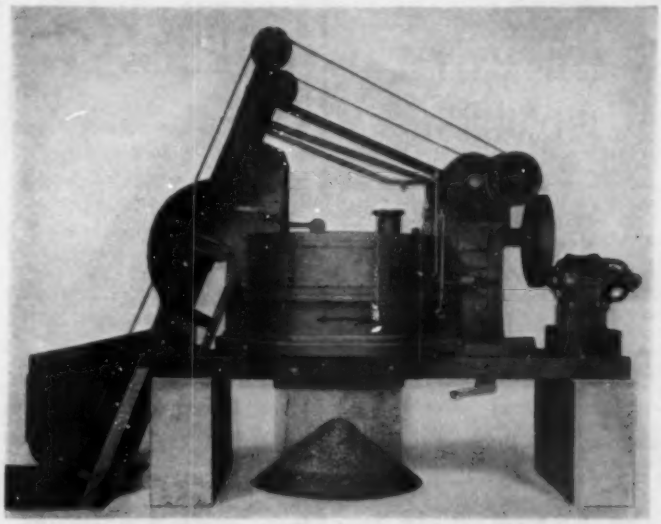

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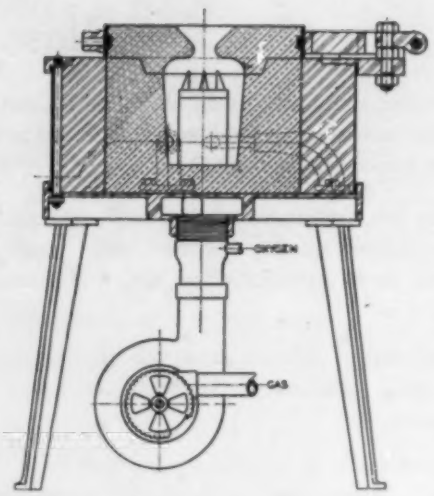

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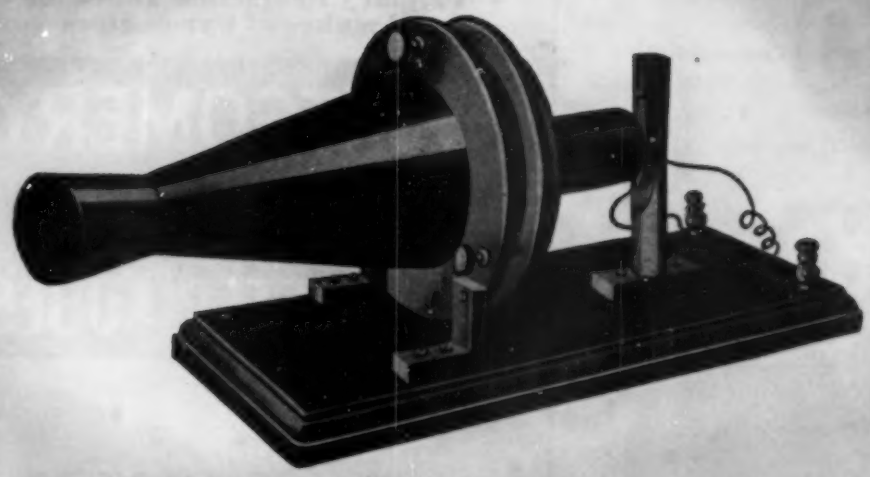

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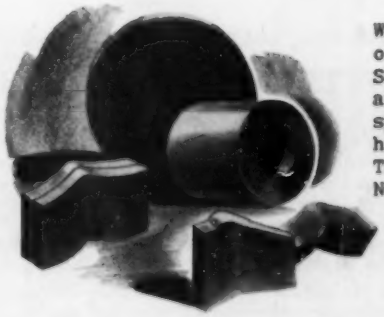

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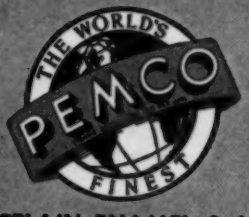

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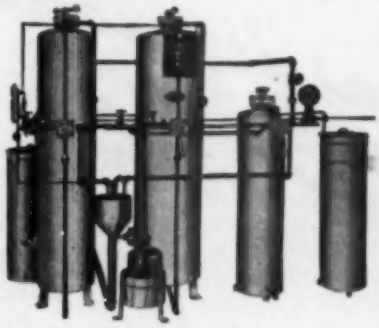

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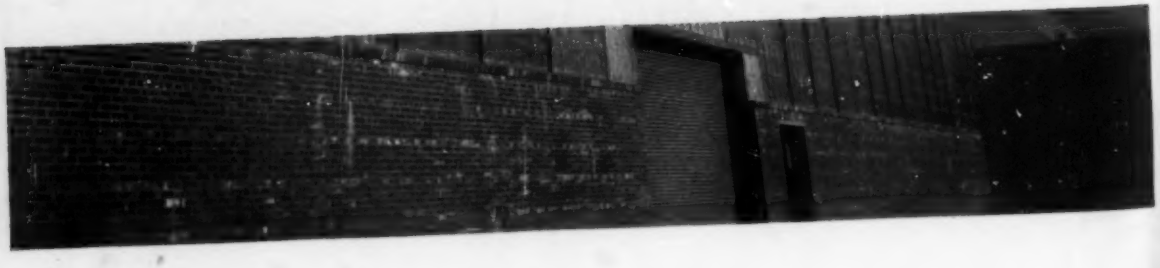

THE JOURNAL

OF

THE AMERICAN CERAMIC SOCIETY

Vol. 25 February 15, 1942 No. 4

GLASSFORMING NATURE OF OXIDES WITH SPECIAL REFERENCE TO TANTALA, TITANIA, AND BERYLLIA*

By Kuan-Han Sun and Alexander Silverman

Abstract

The ρ value of an oxide, which is defined as the ratio of the cation radius to the oxygen radius, has been considered as one of the criteria for determining whether an oxide is a network former, that is, a glassformer or an intermediate. Most of all the known network formers have ρ values smaller than 0.414, which is the limit for a tetrahedral structure.

The experimental facts as to whether Ta_2O_5 alone forms a glass are in controversy. A study of its ρ value reveals that Ta_2O_5 is probably not a glassformer. The same is true for Cb_2O_5. The ρ value of TiO_2 also indicates that it is not a glassformer. The small ρ value of BeO leads to the belief that BeO is an intermediate oxide in glass. Further evidence, based on the physical and chemical properties of beryllia-containing glasses, has been established to show the validity of the viewpoint.

It has been pointed out that all of the elements whose oxides are glassformers or intermediates may be grouped together in the periodic table. It has also been noted that, of all the possible oxide glassformers, the most important are SiO_2, B_2O_3, P_4O_{10}, and GeO_2.

I. Introduction

Oxides which constitute a component in glass may usually be classified in three groups, namely, the glassformers, the modifiers, and the intermediate oxides. The glassformers and the intermediates may be also called network formers as far as the present study is concerned. Zachariasen[1] has discussed glassformers relating to the atomic arrangement in glass, and he has made a list of these, namely, B_2O_3, SiO_2, GeO_2, P_2O_5, As_2O_5, P_2O_3, As_2O_3, Sb_2O_3, Sb_2O_5, V_2O_5, Cb_2O_5, and Ta_2O_5. He has also mentioned that all of the known glassformers assume triangular or tetrahedral networks. In his theoretical discussion on the nature of the formation of glass, Hägg[2] has stated that it is such strongly bonded units as AO_4 and AO_3, in which A may be an element like Si, P, B, and others, which are primarily responsible for "irregular groups," that lead to the formation of a glass. It then follows that a study of radii ratios of cations to oxygen, which determine the coordination number of cations in these oxides, should offer a simple, though not final, criterion as to whether or not an oxide could be a network former. The radii of cations have been calculated by Pauling[3] on the basis of wave mechanics and of the known interionic distances of five compounds. The radius of oxygen is usually not constant and varies from about 1.1 to 1.4 a.u., depending on the cation with which it combines. Although data for the interionic distances, M–O, are abundant and accurate, there is no accurate way to assign radii for M and O in the particular binding. For simplicity, the writers have adopted the Pauling values of cationic radii and 1.3 a.u. as an average radius for oxygen in the calculation of the radii ratio of cation to oxygen, ρ. This ratio is defined as

$$\rho = r_C/r_O.$$

Where r_C and r_O = radii of cation and oxygen, respectively.

The ρ values for various oxides have been calculated and listed in Table I.

(1) Group A Oxides

In group A (Table I), B_2O_3, SiO_2, G [illegible] and P_4O_{10}

* Received June 30, 1941; revised copy received October 29, 1941.

Contribution No. 435 from the Department of Chemistry, University of Pittsburgh, Pittsburgh, Pa.

[1] W. H. Zachariasen, "Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54** [10] 3841–51 (1932); *Ceram. Abs.*, **12** [4] 145 (1933).

[2] G. Hägg, "The Vitreous State," *Jour. Chem. Phys.*, **3** [1] 42–49 (1935); *Ceram. Abs.*, **14** [7] 161 (1935).

[3] Linus Pauling, Nature of Chemical Bond and Structure of Molecules and Crystals, 2d ed., Chapt. II and X. Cornell University Press, Ithaca, N. Y., 1940. 429 pp.; *Ceram. Abs.*, **19** [1] 28 (1940).

form a glass very easily. Morey[4] has mentioned that V_2O_5 forms a glass, although Hägg[2] has failed to prepare such a glass. The glass formation of As_4O_{10} and of As_2O_4 has been indicated by Mellor.[5] Information about Sb_4O_{10} and Sb_2O_4 is lacking, but these compounds probably will form a glass under suitable conditions.

TABLE I

ρ VALUES OF VARIOUS COMPOUNDS

Compounds	r_C (in a.u.)	ρ
	A group	
B_2O_3	0.20	0.15
CO_2	0.15	0.12
SiO_2	0.41	0.32
GeO_2	0.53	0.41
P_4O_{10}	0.34	0.26
As_4O_{10}	0.46*	0.35
V_2O_5	0.59	0.45
Sb_4O_{10}	0.60*	0.46
As_2O_4 and Sb_2O_4	no values	
	B group	
P_4O_6		
As_4O_6	0.66*	0.51
Sb_4O_6	0.86*	0.66
	C group	
BeF_2	0.31†	0.228
$ZnCl_2$	0.74	0.408
	D group	
Cb_2O_5	0.70	0.54
Ta_2O_5	0.73‡	0.56
TiO_2	0.68	0.52
Al_2O_3	0.50	0.38
BeO	0.31	0.24

* O. Hassel, Crystal Chemistry, p. 31. Theodor Steinkoff, Dresden, Germany, 1934. 114 pp.; *Ceram. Abs.*, **13** [8] 225 (1934).

† The radii of F and Cl are taken as 1.36 and 1.81 a.u., respectively.

‡ K.-H. Sun and A. Silverman, "Tantalum Glass: K_2O-Ta_2O_5-SiO_2 Series," *Jour. Amer. Ceram. Soc.*, **24** [5] 160–67 (1941).

From geometry and from experience, it is known that the ρ value of an oxygen tetrahedron with a cation in the center usually lies between 0.225 and 0.414. A triangular structure results for a ρ value below 0.225, and for that value above 0.414, an octahedral configuration occurs. It is interesting to see that, except for V_2O_5 and Sb_4O_{10}, the ρ values of all of the oxides in group A lie below 0.414. Inasmuch as the radii of cations and oxygen are chosen arbitrarily, the slightly larger ρ values of V_2O_5 and Sb_4O_{10} may be erroneous. In other words, all of the oxides in this group are glassformers, and their configurations are triangular for B_2O_3 and tetrahedral for others. Although CO_2 or C_2O_3 glass has not been reported, a glass with the composition, $K_2Mg(CO_3)_2$, was made by Eitel and Skaliks[6] under a CO_2 pressure of 1200 atmospheres.

(2) Group B Oxides

The properties of As_4O_6 glasses and of Sb_4O_6 glasses of group B (Table I) have been studied by Kordes.[7] Their ρ values, all of which are greater than 0.414, suggest that they are not network formers. An examination of the corresponding crystalline structures, however, shows that As (III) or Sb (III) forms a tetrahedron with 3 oxygens, and it does not remain inside a tetrahedron formed by 4 oxygens in the usual way. The binding between As (III) or Sb (III) with O is rather covalent in nature, and these glasses should be interpreted as a kind of organic rather than inorganic glass.

(3) Group C Oxides

Group C (Table I) contains ρ values for some nonoxide glasses, which are below 0.414 as is to be expected.

(4) Group D Oxides

The oxides listed in group D (Table I) will be discussed in considerable detail in the following paragraphs.

Zachariasen[1] has listed Cb_2O_5 and Ta_2O_5 as glassformers, and Morey[8] has also mentioned that Ta_2O_5 alone forms a glass. From their ρ values, however, as shown in group D (Table I), it would be suspected that they are not glassformers. The present authors have tried to make some K_2O-BaO-Ta_2O_5 glass in the composition ranges in which glasses might be expected, but none were obtained. Navias[9] states that he failed to prepare a Ta_2O_5 glass after he had tried various methods. Although the experimental facts are in controversy, the authors are inclined to believe that Ta_2O_5 is not a glassformer. No information relating to Cb_2O_5 is available, but from its ρ value, it may be expected to behave in a manner similar to Ta_2O_5.

If TiO_2 were a glassformer, the refractive index of the glass would be much higher than that of a diamond.* Zachariasen[1] states that "all attempts to make a TiO_2 or an Al_2O_3 glass have been in vain." On studying the system Na_2O–TiO_2, Washburn and Bunting[10] state that "mixtures of these two oxides were found to crystallize so readily that it was not necessary to employ the laborious quenching method, in fact it could not

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[4] G. W. Morey, Properties of Glass, American Chemical Monograph Series, No. 77, p. 75. Reinhold Publishing Corp., New York, 1938. 561 pp.; *Ceram. Abs.*, **18** [2] 48 (1939).

[5] J. W. Mellor, Comprehensive Treatise on Inorganic and Theoretical Chemistry, Vol. IX, pp. 137–38. Longmans, Green & Co., Ltd., London, 1929; *Ceram. Abs.*, **8** [5] 373 (1929).

[6] W. Eitel and W. Skaliks, "Über einige Doppelcarbonate der Alkalien und Erdalkalien," *Z. anorg. allgem. Chem.*, **183** [3] 263–86 (1929); *Ceram. Abs.*, **9** [4] 309 (1930).

[7] E. Kordes, "Physikalisch-chemische Untersuchungen über Feinbau von Gläsern, III," *Z. physik. Chem.*, **B43** [3] 173–90 (1939).

[8] G. W. Morey, "Optical Glass," U. S. Pat. 2,150,694, March 14, 1939; *Ceram. Abs.*, **12** [5] 127 (1939).

[9] Comments by L. Navias, General Electric Co., on paper by K.-H. Sun and A. Silverman, "Tantalum Glass: K_2O-Ta_2O_5-SiO_2 Series," *Jour. Amer. Ceram. Soc.*, **24** [5] 160–67 (1941).

* The refractive index of diamond is 2.417 for the D-line; crystalline $PbTiO_3$ is 2.7 (D. W. Robertson, "Lead Titanate," *Ind. Eng. Chem.*, **28** [2] 216–18 (1936)). If TiO_2 were a glassformer, $PbTiO_3$ glass could be made and its refractive index should not deviate much from that of the crystalline state.

[10] E. W. Washburn and E. N. Bunting, "Na_2O–TiO_2 System," *Bur. Stand. Jour. Research*, **12** [2] 239 (1934); R.P. 648; *Ceram. Abs.*, **13** [5] 131 (1934).

be used on account of the rapidity of crystallization." It is safe, therefore, to say that TiO_2 is not a glassformer. In the periodic table, Ti is in family A and Si and Ge are in family B in Group IV. The families, however, are not necessarily related. The larger ρ value of Ti indicates its dissimilarity to Si and Ge.

The low ρ values of Al_2O_3 and BeO, shown in group D (Table I), indicate that they are network formers. Because Al_2O_3 and BeO alone do not form a glass, they must be intermediate oxides, and Al_2O_3 is known to be an intermediate oxide.

The role of BeO deserves additional investigation. The senior author has advanced a theory covering isomorphous substances in glass and has grouped the oxyions, silicon, aluminum, and beryllium together after a study of opal glass.[11] It may be possible to establish BeO as one of the intermediate oxides in glass.

An oxide, to be classed as an intermediate oxide, must have the ability to form the network or the backbone of glass as well as to act as a modifier which only fills the holes in the backbone. The following discussion will indicate the formation of BeO_4 networks in glass and its behavior as a backbone of glass.

II. Role of Beryllia

(*a*) X-ray studies[12] have revealed the fact that in all crystalline compounds of beryllium, the latter always takes a four-fold coordination and forms the BeO_4 group. Beryllium fluoride (BeF_2), which has about the same ρ value as that of BeO, forms a glass. The reason that BeO alone will not form a glass is because of the deficiency of oxygen in the oxide.* As Be is surrounded by 4 oxygens in BeO, each oxygen must in turn be surrounded by 4 Be. This is against one of the rules formulated by Zachariasen,[1] who suggested that oxygen should take only two-fold coordination in a network former. If there were enough oxygens, however, as there always will be in glass, Be should behave as a glassformer as is the case in BeF_2.

(*b*) Beryllium resembles aluminum in many respects. It is well known to a student of inorganic chemistry that the properties of beryllium and aluminum, like those of boron and silicon, are similar. A semiquantitative expression, taking values of these elements in the electronegativity scales as devised by Pauling,[3] is as follows:

Be	1.5	B	2.0	P	2.1
Al	1.5	Si	1.8		

It is interesting to note that Be and Al have the same value in the electronegativity scale.

Because of the instability of early products, phosphate glasses for years were overlooked and studies on this type have been revived only recently. Tillyer[13] has mentioned that a glass containing 75% of phosphorus pentoxide is not attacked by hydrofluoric acid (he probably referred to an aluminum-phosphate glass). Kreidl and Weyl[14] have shown that $AlPO_4$ glass is very stable, indicating the alternating network formation of the PO_4 and AlO_4 groups. A beryllium-phosphate glass was made about two years ago by Young† and, to the knowledge of the present authors, this glass has not been attacked by moisture. Other stable beryllium-phosphate glasses have been reported recently.[15] These observations would indicate that BeO could be as good an intermediate oxide as Al_2O_3.

(*c*) A qualitative method that may be used to distinguish between a network former and a modifier is to compare their effect on such physical properties of glass as coefficients of thermal expansion and hardness. The modifier usually loosens up the structure of the glass and causes a higher coefficient of thermal expansion and a lower hardness. In the study of soda-beryllia-silica glasses, Rencker[16] showed that the replacement of silica by beryllia at constant soda content has no effect on the thermal expansion of the glass. In soda-lime-silica glasses, however, it is easy to see from the isoexpansion curves of Schmid, Finn, and Young[17] that the replacement of silica by lime at constant soda content results in an increase of thermal expansion. It is obvious that beryllia resembles silica, the glassformer, rather than lime, the modifier. Further evidence on expansion may be observed by considering the additive factors of linear expansion for various oxides. These factors of expansion for various oxides as summarized by Sun and Silverman[18] indicate that for such modifiers as CaO, ZnO, BaO, PbO, and others, the factors lie in the order of magnitude of 10×10^{-6} to 20×10^{-6} and for those of Li_2O, Na_2O, K_2O, Rb_2O, and others in the

[11] A. Silverman, "Effect of Isomorphous Substances on Glass," *Jour. Amer. Ceram. Soc.*, **24** [7] 243 (1941).

[12] W. L. Bragg, Atomic Structure of Minerals. Cornell University Press, Ithaca, N. Y., 1937. 292 pp.; *Ceram. Abs.*, **17** [6] 231 (1938).

[13] E. D. Tillyer, "Optics and the Glass Industry," *Jour. Optical Soc. Amer.*, **28** [1] 1–4 (1938); *Ceram. Abs.*, **17** [11] 351 (1938).

* The low electrical conductivity of molten BeF_2 has led Hägg (see footnote 2) to the erroneous conclusion that BeF_2 is not an ionic compound as compared with BeO and that their properties with respect to glass formation are not similar. From Pauling's electron-negativity scale (see footnote 3), which is a good measure of ionic binding, it is revealed that the Be-F binding should be more ionic in nature than in Be-O. The low electrical conductivity of molten BeF_2 should be attributed to the rigid BeF_4 networks, which are so tightly held that Be^{++} and F^- can not move freely.

[14] N. J. Kreidl and W. A. Weyl, "Phosphates in Ceramic Ware: IV, Phosphates in Glasses," *Jour. Amer. Ceram. Soc.*, **24** [11] 372–78 (1941).

† Private communication from J. C. Young of the National Bureau of Standards, Washington, D. C.

[15] E. D. Tillyer, H. R. Moulton, and T. M. Gunn, "Glass Composition," U. S. Pat. 2,226,418, December 24, 1940; *Ceram. Abs.*, **20** [3] 68 (1941).

[16] (*a*) E. Rencker, "Etude dilatometrique de quelques verres ternaires silice-soude-glucine," *Compt. rend.*, 197, 840–43 (1933); *Ceram. Abs.*, **14** [4] 83 (1934); (*b*) "Dilatometric Study of Some Ternary Glasses," *Bull. Soc. Chim.*, **2** [5] 1389–1407 (1935); *Chem. Abs.*, **29**, 7176 (1935); *Ceram. Abs.*, **20** [9] 214 (1941).

[17] B. C. Schmid, A. N. Finn, and J. C. Young," Thermal Expansions of Some Soda-Lime-Silica Glasses as Functions of Composition," *Bur. Stand. Jour. Research*, **12** [4] 421–28 (1934); R. P. 667; *Ceram. Abs.*, **13** [7] 177 (1934).

[18] K.-H. Sun and A. Silverman, "Additive Factors for Calculating the Coefficient of Thermal Expansion of Glass from Its Composition," *Glass Ind.*, **22** [3] 114–15, 125 (1941); *Ceram. Abs.*, **20** [6] 140 (1941).

TABLE II

GROUPING OF ELEMENTS WHOSE OXIDES ARE GLASSFORMERS OR INTERMEDIATES (INSIDE HEAVY LINES)

I	II	III	IV	V	VI	VII	VIII	O
A B	A B	A B	A B	A B	A B	A B		
H								He
Li	Be	B	C	N	O	F		Ne
Na	Mg	Al	Si	P	S	Cl		A
K	Ca	Sc	Ti	V	Cr	Mn	Fe Co Ni	
Cu	Zn	Ga	Ge	As	Se	Br		Kr
Rb	Sr	Y	Zr	Cb	Mo	Ma	Ru Rh Pd	
Ag	Cd	In	Sn	Sb	Te	I		Xe
Cs	Ba	R.E.	Hf	Ta	W	Re	Os Ir Pt	
Au	Hg	Tl	Pb	Bi	Po	Am		Rn
Va	Ra	Ac	Th	Pa	U			

order of magnitude of about 25×10^{-8} to 60×10^{-8}. The value for such glassformers as SiO_2 lies in the region of 0.5×10^{-8} to 2×10^{-8}, which is one tenth or less than that of the modifiers. There are three values for beryllia. The Mayer and Havas[19] value of 15.7×10^{-8} should be discarded because it was derived from only two glasses that contained less than 5% of BeO. Rencker[16] derived a value of 2×10^{-8}, the same value he assigned for silica, from a series of fifteen soda-beryllia-silica glasses. The Gilard and Dubrul[20] value of -4×10^{-8} seems doubtful as to its absolute value, but it is obvious from their curve that the value is of the right order of magnitude. Gilard and Dubrul used Becker's expansion data of fifteen soda-beryllia-silica glasses for the evaluation of the factor. From the Rencker and from the Gilard and Dubrul values for beryllia, it is safe to say that the BeO has about the same order of thermal expansion as SiO_2 in glass.

Studies by Lai and Silverman[21] and by Becker[22] on the hardness of beryllia-containing glasses also indicate that the hardness of soda-beryllia-silica glasses is always greater than that of the molecularly corresponding magnesia and lime glasses, whereas the corresponding alumina glasses have about the same hardness as the beryllia glasses. It is quite clear, therefore, that beryllia behaves more like a network former than a modifier and may be called an intermediate.

Although these considerations show that beryllia is an intermediate oxide, the low valency of beryllium may indicate that the binding force between beryllium and oxygen is weaker than in glassformers such as B_2O_3 and SiO_2.

III. Conclusions

From the foregoing discussion, the writers suggest that the magnitude of the ρ values could be used as one of the criteria in deciding whether an oxide or a compound is a network former, that is, a glassformer or an intermediate oxide. It is also interesting to note from Table II that all of the elements whose oxides are glassformers or intermediates are grouped together in the periodic table. The nature of oxides of Group VI elements of the periodic table is not yet clear. From the study by Navias and Gallup[23] on SeO_2 glasses, it might be stated that SeO_2 does not act as a glassformer. Hägg[2] has predicted that SO_3 might form a glass.

Of the oxides of all of the elements in the periodic table, only a limited number of oxides are glassformers. Among these, SiO_2, B_2O_3, P_4O_{10}, and GeO_2 are probably the most important. This information may be valuable to those who are seeking new glasses.

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[19] M. Mayer and B. Havas, "Coefficient of Expansion of Enamels in Relation to Their Chemical Composition," *Sprechsaal*, **44**, 188–90, 207–209, 220–22, (1911); *Jour. Soc. Glass Tech.*, **5**, 7A (1921).

[20] (*a*) P. Gilard and L. Dubrul, "Calculating Coefficient of Expansion of Silicate Glasses," *Verre & Silicates Ind.*, **5** [7] 122–25; [8] 141–45 (1934); *Jour. Soc. Glass Tech.*, **18**, 221–23A (1934); *Ceram. Abs.*, **13** [9] 232 (1934); (*b*) Les Bases Physico-Chimiques de l'Industrie du Verre, pp. 76–77. Dunod, Paris, 1937. 223 pp.; *Ceram. Abs.*, **17** [10] 327 (1938); (*c*) "Calculation of Physical Properties of Glass: II, Expansion and Density," *Verre & Silicates Ind.*, **9** [3] 25–28; [4] 37–39; [5] 50–52 (1938); *Jour. Soc. Glass Tech.*, **223**, 129–31A (1938); *Ceram. Abs.*, **18** [4] 95 (1939).

[21] C. F. Lai and A. Silverman, "Beryllium Glass," *Jour. Amer. Ceram. Soc.*, **11** [7] 535–41 (1928).

[22] C. A. Becker, "Chemical and Physical Investigation on Beryllium Glasses," *Sprechsaal*, **67** [10] 137–39; [11] 152–55 (1934); *Ceram. Abs.*, **13** [8] 203 (1934).

[23] L. Navias and J. Gallup, "Selenium Dioxide as a Constituent of Glasses," *Jour. Amer. Ceram. Soc.*, **14** [6] 441–49 (1931).

CAN SILICON TAKE A SIX-FOLD COORDINATION IN GLASS?*

By Kuan-Han Sun and Alexander Silverman

Abstract

A six-fold coordination for silicon in a certain type of synthetic crystal has been reported in the literature. A theory of partial formation of six-fold coordination for silicon in glass has been advanced after the atomic sizes, composition of the glasses, valence rules, and experimental facts are given consideration.

I. Introduction

The junior author recently† raised the following question: "Can silicon take a coordination number of six in glass?" The reasons for this question are given in the following study.

The interionic‡ distance between silicon and oxygen, Si–O, has been determined experimentally by Warren and his co-workers[1] to be 1.62 a.u. The ionic radii of silicon, $r_{Si^{4+}}$, and oxygen, $r_{O^{--}}$, have been evaluated by Goldschmidt,[2] theoretical data have been given by Pauling,[3] and Kordes[4] has carried on further development work. Their values are listed in Table I.

TABLE I

IONIC RADII* OF Si^{4+} AND O^{--} AND THEIR ρ VALUES

	$r_{Si^{4+}}$	$r_{O^{--}}$	r_{Si-O}	$r'_{O^{--}} = 1.62 - r_{Si^{4+}}$	$\rho = r_{Si^{4+}}/r_{O^{--}}$
Goldschmidt[2]	0.35†	1.32	1.67	1.27	0.276
Pauling[3]	.41	1.40	1.81	1.21	.338
Kordes[4]	.43	1.19	1.62	1.19	.370

* In angstrom units.

† Goldschmidt's value for $r_{Si^{4+}}$ was 0.39 a.u., which was derived on the assumption that the coordination number is 6; in order to get the corresponding value for the four-fold coordination, the Pauling conversion factor (0.92) (see footnote 3) has been used to yield the value of 0.35 a.u.

It is clear from Table I that the Goldschmidt and Pauling values yield an interionic distance of Si–O greater than that of the experimental value, 1.62 a.u. In order to fit the experimental value, either the radii of Si^{4+} or of O^{--} or both should be reduced. As Si^{4+} is much smaller and contains higher charges than O^{--}, it is reasonable to assume that the radius of Si^{4+} remains unchanged and that the reduction of interionic distance Si–O is due entirely to the reduction of $r_{O^{--}}$ alone. The actual radius of oxygen in glass may thus be calculated by subtracting the value of $r_{Si^{4+}}$ from the experimental value of Si–O, 1.62 a.u., and it may be denoted as $r'_{O^{--}}$ (Table I). The variation of the radius of oxygen would not affect the experimental O–O distance, 2.65 a.u., so long as the Si–O distance remains the same. The radii of Si^{4+} and O^{--} thus adopted will give values of 0.276, 0.338, and 0.370 for the radii ratios of Si^{4+} to O^{--}, ρ, respectively, for the data derived by Goldschmidt, Pauling, and Kordes. From geometry, the limiting value of ρ (which is the radii ratio of cation to anion) for a tetrahedral structure is known to be 0.225 a.u. in order to have anion contact. All values greater than 0.225 would indicate a structure of a non-anion contact. The ρ values derived from Table I suggest that the oxygens in the tetrahedron do not come into contact with each other and that the silicon ion is located in the space in contact with 4 oxygens rather than being tightly held inside the hole made by the 4 contact oxygens. Figure 1 is a schematic diagram which shows the structure of a SiO_4 tetrahedron without having 4 oxygens in contact, as compared with 4 oxygens in contact. If the view of the writers is correct, the obstacle to the six-fold coordination of silicon has been removed because the geometric configuration would allow the forces from the silicon ion to reach neighboring oxygens other than the 4 regular oxygens.

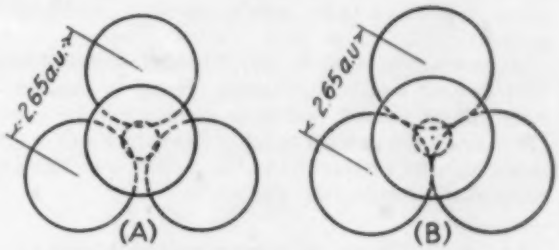

FIG. 1.—Schematic structure of a SiO_4 tetrahedron: (*A*) without oxygen contact (view of the authors); (*B*) with oxygen contact (traditional view).

In the X-ray diffraction study of glass by Fourier analysis, the area under the Si–O peak of the radial distribution curve should correspond to the coordination number for silicon. The experimental values vary from

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† At a session of the Glass Division held during the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 1 and 2, 1941.

‡ The word "ionic" or "ion" hereafter used should be interpreted to mean that the bonds in glass are largely ionic but not necessarily of the extreme type such as ions in alkali halogenides.

[1] B. E. Warren, "X-Ray Diffraction Study of Structure of Glass," *Chem. Rev.*, 26 [2] 237–55 (1941).

[2] V. M. Goldschmidt, "Geochemical Distribution Laws of Elements: VIII, Researches on Structure and Properties of Crystals," *Skrifter Norske Videnskaps-Akad., Oslo, I, Mat. Naturw. Klasse*, 1926, No. 8, pp. 7–156 (1927); *Ceram. Abs.*, 6 [7] 308 (1927).

[3] Linus Pauling, Nature of Chemical Bond and Structure of Molecules and Crystals, 2d ed., Chapt. X. Cornell University Press, Ithaca, N. Y., 1940. 429 pp; *Ceram. Abs.*, 19 [1] 28 (1940).

[4] (*a*) E. Kordes, "Ermittelung von Atomabständen aus der Lichtbrechung, II," *Z. physik. Chem.*, **B44** [5/6] 327–43 (1939); p. 342.

(*b*) E. Kordes, "Ionenradien und periodisches System," *ibid.*, **B43** [3] 213–28 (1939).

4.3 for vitreous silica, reported by Warren, Krutter, and Morningstar,[5] to 4.8 for some soda-lime-silica glasses investigated by Biscoe.[6] The deviation from 4.0 was explained by the investigators in the field as the result of experimental errors.

The X-ray analysis behaves normally in the case of B_2O_3 glass.[5] The experimental coordination number is 3.1 as compared with 3.0, which is expected theoretically. No matter what interpretation is placed on the fact that 4.7 or 4.8 could be considered as four for the coordination number of silicon, it is equally justifiable to interpret them as a mixture of four- and six-fold coordinations. Unless the significance of the Fourier analysis is denied, the latter interpretation should be at least equally as good as the former.

Titanium, which occupies a position in the periodic table next to silicon, almost exclusively takes six-fold coordination. There is then no reason why silicon which is only a little smaller than titanium, should not take a six-fold coordination under certain favorable conditions.

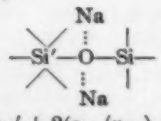
II. Support of Theory

Warren's comment on this question is that the case of six-fold coordination for silicon has never been found in the study of crystalline silicates and that it is improbable. Although a six-fold coordination for silicon does occur, it is unusual. The authors have recently located a case in a crystalline silicate in which silicon takes six-fold coordination. Pauling[7] has stated that "tetrahedral coordination has been observed about Si^{4+} in scores of crystals and octahedral coordination in only one, SiP_2O_7." This fact encouraged the writers to advance a theory of the partial formation of six-fold coordination for silicon in glass, and further evidence is given which favors a partial six-fold coordination for silicon in addition to the regular four-fold coordination in glass.

As an example of this theory, Na_2O is introduced into SiO_2 to form a soda-silica glass. Singly bonded oxygens will be formed, and their number will be equal (1) to twice the number of oxygens in the Na_2O or (2) to the number of Na ions in the Na_2O. The Pauling electrostatic valence rule[8] states that

> In a stable ionic structure, the valence of each anion with changed sign is exactly or nearly equal to the sum of the strengths of the electrostatic bonds leading to it from the adjacent cations, that is, that $\zeta = \sum_i (z_i/n_i)$, in which ζ is the number of charges on the anion; z_i, on the cation; and n_i, the coordination number of the corresponding cation. The summation is taken over the cations at the centers of all the polyhedra of which the anion forms a corner.

According to this rule, then, the so-called doubly bonded oxygens in the SiO_4 unit should have been saturated already.* The doubly bonded oxygens in the SiO_4 unit, therefore have no further ability to form bonds with other surrounding cations. This would result in discarding the schematic structure of soda-silica glass, such as that drawn by Zachariasen and adopted by Warren[1] because it is impossible to have sodium ions surrounded by both singly and doubly bonded oxygens. They must be bonded by singly bonded oxygens alone. Inasmuch as the number of singly bonded oxygens is equal to the number of sodium ions in the soda-silica glass and as the coordination number of sodium ions is six, it follows that each singly bonded oxygen must do six-fold duty. In other words, each of the singly bonded oxygens will be surrounded by 6 sodium ions and each sodium ion will in turn be surrounded by 6 oxygens. This not only is geometrically impossible but it would lead to a situation of crowding and the concentration of all singly bonded oxygens and sodium ions at one spot. For a glass containing 2 mol % (about 2% by weight) of Na_2O, there are about 4 singly bonded oxygens and 4 sodium ions each for each 96 silicon ions; the crowding of singly bonded oxygens and sodium ions would therefore certainly result either in immiscibility or in nonhomogeneity in such a glass. Neither case has been observed. It is clear that the traditional view of glass structure has failed to explain the difficulty. If, however, a partial six-fold coordination of silicon is assumed, it would release some of the so-called doubly bonded oxygens (with respect to silicon) to bond with sodium ions without contradicting the Pauling rule. For example,



$$\zeta_{O^{--}} = z_{Si'}/n_{Si'} + 2(z_{Na}/n_{Na}) + z_{Si}/n_{Si} = 4/6 + 2(1/6) + 4/4 = 2.$$

It is clear that the doubly bonded oxygen can take up sodium ions if a partial formation of six-fold coordination of the silicon is assumed. The sodium ions then can enter any hole made by oxygens whether they are singly or doubly bonded oxygens with respect to the silicons, and no crowding of the sodium ions and the singly bonded oxygens will occur.

The composition of any simple silicate glass may be expressed in a general formula such as $M_mM'_{m'}SiO_n$, in which M and M' may represent the cations, Na^+, Ca^{++}, Pb^{++}, and Fe^{+++}, and m, m', and n, the num-

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[5] (*a*) B. E. Warren, H. Krutter, and O. Morningstar, "Fourier Analysis of X-Ray Patterns of Vitreous SiO_2 and B_2O_3," *Jour. Amer. Ceram. Soc.*, **19** [7] 202–206 (1936).
(*b*) B. E. Warren and J. Biscoe, "Structure of Silica Glass by X-Ray Diffraction Study," *ibid.*, **21** [2] 49–54 (1938).

[6] (*a*) J. Biscoe, "X-Ray Study of Soda-Lime-Silica Glass," *ibid.*, **24** [8] 262–64 (1941).
(*b*) B. E. Warren and J. Biscoe, "Fourier Analysis of X-Ray Patterns of Soda-Silica Glass," *ibid.*, **21** [7] 259–65 (1938).
(*c*) J. Biscoe, M. A. A. Druesne, and B. E. Warren, "X-Ray Study of Potash-Silica Glass," *ibid.*, **24** [3] 100–102 (1941).

[7] Pauling (see p. 382 of footnote 3) did not refer to this exceptional case, but he probably referred to the paper by G. R. Levi and G. Peyronel, "Crystallographic Structure of the Isomorphous Group (Si^{4+}, Ti^{4+}, Zr^{4+}, Sn^{4+}, Hf^{4+}) P_2O_7," *Z. Krist.*, **92**, 190–209 (1935); *Ceram. Abs.*, **16** [1] 44 (1937).

* The electrostatic strength, z/n, for each Si–O bond is 4/4 and, as each oxygen in SiO_2 is bonded to two silicons, the electrostatic strength of the oxygen is just balanced.

ber of particular ions in the glass. Zachariasen[8] has pointed out that, for most glasses, n, which is the number of oxygens per Si, is about 2.5. There are some glasses, however, with extremely interesting compositions such as those shown in Table II.

TABLE II

GLASSES WITH EXTREME COMPOSITIONS

Molecular formulas	Compositions (wt. %)	Authority*
$Pb_{3.01}SiO_{4.01}$	PbO, 91.8; SiO_2, 8.2	Weiller
$Pb_{3.27}Na_{0.322}SiO_{3.921}$	PbO, 90.04; Na_2O, 1.83; SiO_2, 7.99	Merwin and Andersen
$Fe_{0.942}Na_{1.624}SiO_{4.22}$	Fe_2O_3, 40.00; Na_2O, 27.43; SiO_2, 32.57	Bowen, Schairer, and Willems

* P. Weiller, H. E. Merwin and Olaf Andersen, and N. L. Bowen, J. F. Schairer, and H. W. v. Willems are cited, respectively, on pp. 239, 374, and 396 in the book by G. W. Morey, Properties of Glass, American Chemical Monograph Series, No. 77. Reinhold Publishing Corp., 1938. 561 pp.; *Ceram. Abs.*, **18** [2] 48 (1939).

The theory that glass is formed by the interlocking of SiO_4 networks with each other will not explain the formation of glasses such as those shown in Table II in which the number of oxygens per silicon ion are all greater than 4. There must be some SiO_6 networks in such glasses. There are also many glasses with compositions along $Pb_6Na_6SiO_4$. Even in such cases, some SiO_6 structure would be expected to occur rather than SiO_4 alone. The reason is simple. If only SiO_4 structure is assumed, then all of the 4 oxygens around a certain silicon ion will be singly bonded, that is, none of the SiO_4 groups is linked with each other but rather through Pb^{++} and Na^+. Because the coordination numbers of Na^+ and Pb^{++} are equal to or are greater than 6 and because their charges are much less than Si, it follows that the bonds, Pb–O and Na–O would be much weaker than for Si'(six-fold coordination)–O. The partial formation of SiO_6 groups would naturally be expected, which would interlock or link the whole glass with greater forces. Glass, with the composition of $Na_2Ca_{0.7}SiO_{3.7}$ has been made[9] in the familiar soda–lime–silica system. On the average, there is less than one oxygen in every SiO_4 group that is bonded to another SiO_4 group. Such structure, however, is improbable in a three-dimensional network. The partial formation of the SiO_6 group again would eliminate the difficulty, and even pure vitreous silica might have some six-fold coordinated silicons.

Glass is a substance that is frozen from the molten state. It differs from the crystalline state in that it retains some of the "randomness" of the molten state, and it is reasonable to assume there could be some SiO_6 groups in liquid SiO_2 in which the ions are rather free to move. If there are some SiO_6 groups in vitreous silica, some oxygens then will be trebly bonded by silicons. Such a case has been found in the mineral, Be_2SiO_4, in which Be and Si are tetrahedrally bonded by oxygens and each oxygen is trebly bonded by 3 cations.[10]

Unless some other theories are advanced to explain these facts, the partial formation of six-fold coordination of silicon in glass is likely.

Although the writers favor the possibility of six-fold coordination of silicon in glass, the amount of six-fold coordination is believed to be much smaller than the regular four-fold coordination. Glass which is composed entirely of SiO_6 groups probably cannot exist. The "partial" formation of six-fold coordination of silicon, however, is emphasized.

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[8] W. H. Zachariasen, "Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54** [10] 3841–51 (1932); *Ceram. Abs.*, **12** [4] 145; [12] 416 (1933).

[9] See G. W. Morey, *loc. cit.*, p. 386, for properties of glass No. 156.

[10] W. L. Bragg, Atomic Structure of Minerals. Cornell University Press, Ithaca, New York, 1937. 292 pp.; *Ceram. Abs.*, **17** [6] 231 (1938).

EFFECT OF LIGHT ON COLOR OF GLASS*

By A. E. Badger and Axel C. Ottoson

Abstract

This study was restricted to soda-lime-silica glasses which contain various agents used as decolorizers in glass, such as manganese, arsenic, antimony, cerium, and neodymium oxides and metallic selenium.

The prepared glass samples were exposed to the radiation from a quartz-mercury lamp, to sunlight, or to X radiation. Visual observation was supplemented by quantitative measurements of the color changes, using a General Electric automatic recording photoelectric spectrophotometer.

Glasses which contain antimony discolor less readily than similar arsenic-bearing glasses, and cerium, lead, and iron oxides in sufficient amounts minimize the discoloration due to light. Samples exposed to X radiation are usually discolored to a yellowish brown, except in the case of some cerium and iron-bearing glasses which were practically unaffected by the same treatment.

A discussion of the results and those of other investigators is given.

I. Introduction

The fact that some glasses undergo color changes on exposure to light has been noticed in street-lighting globes, window glass, and old bottles. The yellowish tint developed in some glasses was recorded as early as 1867–1872 by Pelouze, Bontemps, and Gaffield.[1] The purple color formed in manganese-bearing glass, which was described by Crookes,[2] exhibits the most pronounced transformation of color except perhaps Löffler's cerium-vanadium couple, which has been studied recently by Upton.[3]

Although the change of color produced in iron-bearing glasses after exposure to light has been suggested as a practical means of decolorizing glass,[4] the phenomenon is usually troublesome in the manufacture of fine glassware owing to the undesirable tint that is developed and to the difficulty of matching replacements. The discoloration of glasses by exposure to light is often called "solarization" or "fading."

The present investigation was planned to study the fading of fine glassware and thus deals with the color changes caused by the presence of small amounts of materials which are placed in the batch as decolorizing agents. Visual observations of the test glasses were supplemented by quantitative measurements of the spectral transmission which were made with a General Electric automatic recording photoelectric spectrophotometer.†

A commercial soda-lime-silica glass was used as a base glass composition with additions of small amounts of various decolorizers. The latter materials consisted of the common decolorizers, such as manganese, nickel, cerium, and neodymium oxides and elemental selenium. Inasmuch as soda niter and arsenic oxide are common additions used to assist in decolorizing glass, some melts of glasses were made using these materials as well as antimony and lead oxides.

Small pieces of glass were cast from each melt. After annealing, they were exposed to the radiation from a quartz-mercury lamp, to sunlight, or to X radiation.

II. Exposure of Glasses

Because the fading of the glasses depends on the time of exposure, certain empirical exposure periods were used as follows: *Ultraviolet exposure:* 120 hr., at a distance of about 8 in. from a quartz-mercury lamp‡; *sunlight exposure:* 60 days, uncovered on a flat unshaded roof (June 20, 1941 to August 18, 1941); and *X radiation:* 40-hr., X radiation from molybdenum target; pinhole removed from one position of X-ray apparatus§).

III. Visual Observations of Fading

A soda-lime-silica batch, consisting of potter's flint 75 gm., sodium carbonate (c.p.) 29 gm., and calcium carbonate (c.p.) 15.3 gm., was used to produce a glass which had a calculated chemical composition of SiO_2 75, Na_2O 17, and CaO 8%. The materials whose effects were to be studied were added to this batch.

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Based on thesis submitted by Axel C. Ottoson in partial fulfillment of requirements for the degree of Bachelor of Science in Ceramic Engineering, University of Illinois.

[1] Refer to Bernard Long, Les Propriétés Physiques et la Fusion du Verre, p. 371. Dunod, Paris, 1933. 489 pp.; *Ceram. Abs.*, 12 [7] 260 (1933).

[2] W. Crookes, "Coloration of Glass by Natural Solar and Other Radiations," *Proc. Roy. Soc.*, **74**, 524 (1904).

[3] L. O. Upton, "Light-Sensitive Glass and Its Application for Ultraviolet Measurements," *Glass Ind.*, 21 [4] 109–12 (1940); *Ceram. Abs.*, 20 [4] 90 (1941).

[4] L. Springer, "Decolorizing Glass Without Decolorizing Agent," *Glashütte*, 70 [46] 597–98 (1940); *Ceram. Abs.*, 20 [3] 65 (1941).

† The authors are indebted to J. O. Kraehenbuehl, Department of Electrical Engineering, University of Illinois, for all measurements of spectral transmission made with the General Electric automatic recording photoelectric spectrophotometer.

‡ Uviarc portable 360-watt tube, No. UA26A2, obtained from the General Electric Vapor Lamp Co., Hoboken, N. J.

§ Appreciation is expressed to G. L. Clark, Department of Chemistry, University of Illinois, for the use of the X-ray equipment.

TABLE I

CHEMICAL ADDITIONS (GRAMS) TO 100 GRAMS OF SODA-LIME-SILICA GLASS (SiO_2 75, Na_2O 17, AND CaO 8%)

Series No.	Additions (gm.)									
I	Blank test (no addition)		Fe_2O_3	0.25	MnO_2	0.25	Se	0.10	$Nd_2(CO_3)_3$	1.50	NiO	0.025
II*	Blank test		Fe_2O_3	.25	MnO_2	.25	Se	.10	$Nd_2(CO_3)_3$	1.50	NiO	.025
III	As_2O_3	0.50	Fe_2O_3	.25	MnO_2	.25	Se	.10	$Nd_2(CO_3)_3$	1.50	NiO	.025
			As_2O_3	.50	As_2O_3	.50	As_2O_3	.50	As_2O_3	0.50	As_2O_3	.50
IV	Sb_2O_3	0.50	Fe_2O_3	.25	MnO_2	.25	Se	.10	$Nd_2(CO_3)_3$	1.50	NiO	.025
			Sb_2O_3	.50	Sb_2O_3	.50	Sb_2O_3	.50	Sb_2O_3	0.50	Sb_2O_3	.50
V	$Ce(OH)_3$	0.50	Fe_2O_3	.25	MnO_2	.25	Se	.10	$Nd_2(CO_3)_3$	1.50	NiO	.025
			$Ce(OH)_3$	.50	$Ce(OH)_3$	.50	$Ce(OH)_3$	.50	$Ce(OH)_3$	0.50	$Ce(OH)_3$	.50
VI	Pb_3O_4	3.0	Fe_2O_3	.25	MnO_2	.25	Se	.10	$Nd_2(CO_3)_3$	1.50	NiO	.025
			Pb_3O_4	3.0	Pb_3O_4	3.0	Pb_3O_4	3.0	Pb_3O_4	3.0	Pb_3O_4	3.0

* In series II, a niter batch was used throughout, and 4.9 gm. of $NaNO_3$ were substituted for 3.0 gm. of Na_2CO_3.

Table I lists these additions with their amounts in grams.

The glass batches were melted in porcelain crucibles which were placed in saggers to prevent the furnace gases from coming in contact with the glass. A gas-fired furnace was used to bring the temperature gradually to 1500°C. in about 4 hr., and it was held at that temperature for an additional hour. The glasses were allowed to cool in the furnace, after which they were removed and broken from the pots. The fragments were remelted in platinum crucibles and were cast in the form of bars 1.5 by 1.5 by 5.0 cm. These bars were then annealed for 12 hr. at 500°C. and cooled slowly over another 12-hr. period.

Three specimens were cut from each of the annealed bars with a diamond-wheel saw. After grinding and polishing, one set of specimens was given the ultraviolet-light treatment for 120 hr. and another was exposed to X radiation for 40 hr. Visual comparisons of the color of the original glass specimen were made with that of the exposed specimen. These comparisons showed (1) that exposure to X rays usually produced a brownish discoloration in the glasses (those glasses with ceria additions[5] and some with iron oxide additions were practically unaffected) and (2) that the ultraviolet light caused the following effects: (*a*) only slight fading occurred in the glasses of series I, which contained additions of iron, manganese, selenium, neodymium, or nickel (the change in the selenium-bearing glass was most evident); (*b*) because the glasses in series II were

[5] F. Eckert, "Peculiar Case of Color Change and Luminescence in Glass," *Z. tech. Physik.*, **7**, 301 (1926); *Ceram. Abs.*, **6** [7] 277 (1927).

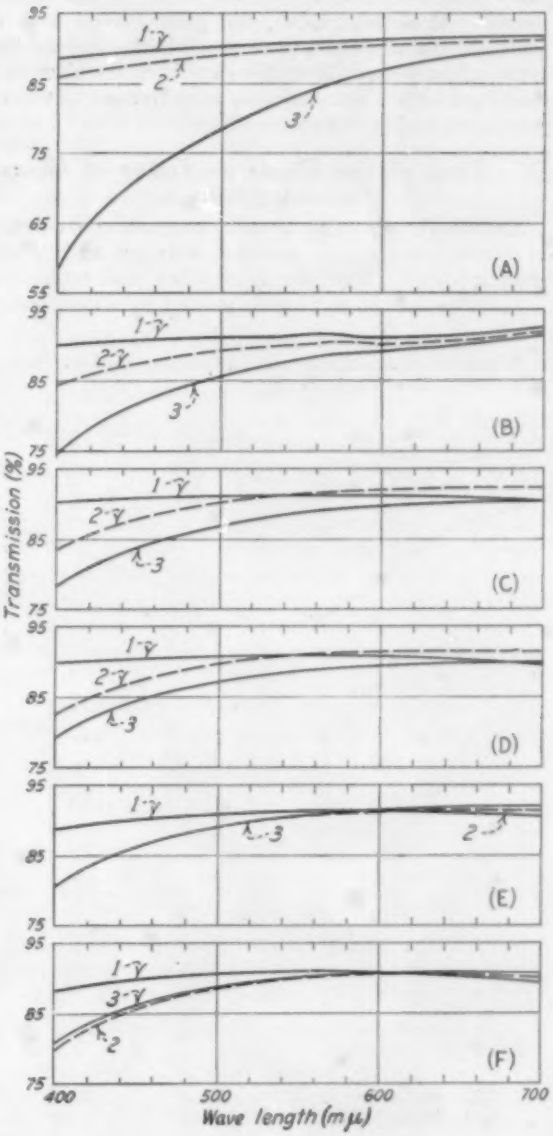

FIG. 1 (*A*) to (*F*), inclusive.—Parent soda-lime-silica batch prepared from pure materials contains 0.5 part of As_2O_3 in batch; increasing amounts of Fe_2O_3 up to 0.06 part were added to different batches of this glass; samples were exposed to sunlight and to ultraviolet light; each figure shows original transmission of glass, curve (1); transmission after exposure to sunlight, curve (2); and transmission after exposure to ultraviolet light, curve (3).

	Fe_2O_3 addition	Thickness (mm.)		Fe_2O_3 addition	Thickness (mm.)
(*A*)	None	3.07	(*D*)	0.03	3.13
(*B*)	0.01	3.12	(*E*)	.04	3.13
(*C*)	.02	3.12	(*F*)	.06	3.12

melted from batches containing niter, the manganese glass was purple due to the trivalent manganese; marked fading occurred only in the selenium and neodymium glasses; (*c*) all glasses in series III, which were made from arsenic-bearing glasses, faded except those with iron or nickel additions; the antimony-bearing glasses in series IV showed similar but less-pronounced changes; and (*d*) ceria and lead glasses (series V and VI) showed no tendency to marked fading.

The original color of irradiated glasses may be restored by heating the glass at a moderate temperature. This process is usually accompanied by thermoluminescence, which is particularly strong in fused quartz glass. To investigate this phenomenon, a sample of fused quartz glass, which was exposed to X radiation, was found to possess a brown color on the face nearest the X-ray tube which gradually changed to purple on the interior of the glass. The glass was then placed in an electric furnace whose temperature was raised slowly. At about 245°C., the glass glowed with a greenish tint which changed to a bluish color as the temperature rose. When the glow from the glass was examined with a spectroscope, a continuous spectrum was found and no lines were visible.

IV. Effect of Iron Oxide on Fading of Glasses Containing Arsenic

In order to prepare a glass with as nearly zero content of iron as possible, c.p. materials were melted in platinum crucibles. The source of silica was tetraethyl silicate,* which on hydrolysis yielded pure amorphous silica.

* May be obtained from the Carbide and Carbon Chemicals Corp., New York, N. Y.

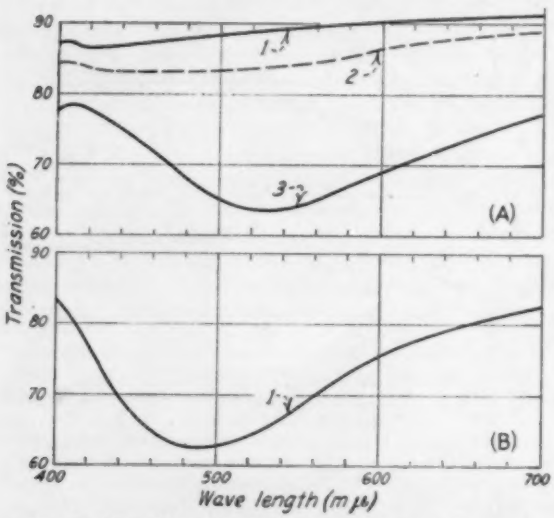

FIG. 2 (*A*).—Nearly colorless glass, curve (1), containing manganese and arsenic transformed to purple glass, curve, (3) by ultraviolet light; sunlight, curve (2), gives an intermediate effect.

(*B*) Normal purple color of manganese-bearing glass shown for comparison.

	Addition	Thickness (mm.)
(*A*)	As_2O_3 0.5 + MnO_2 0.25	2.99
(*B*)	MnO_2 0.25 (containing niter)	3.02

A series of seven glasses was prepared from these pure batch materials, each containing the same amount of arsenic oxide but with increasing amounts of iron oxide. The parent batch consisted of silica 75, Na_2CO_3 26, $NaNO_3$ 4.9, $CaCO_3$ 15.3, and As_2O_3 0.5 part. Iron oxide was introduced in this batch in steps varying from zero to 0.06 part of Fe_2O_3, and the glasses were prepared by the regular procedure.

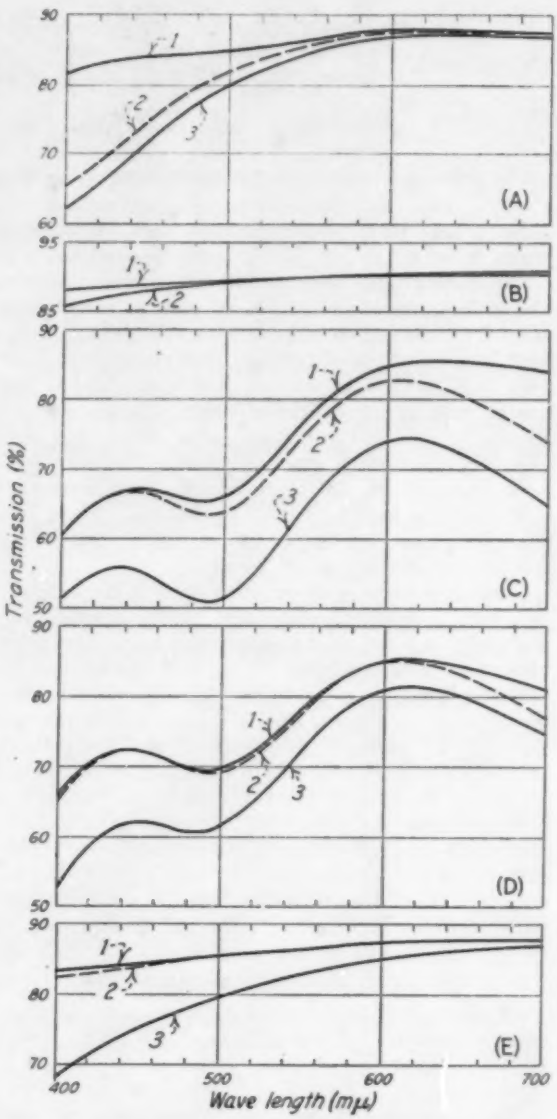

FIG. 3, (*A*) through (*E*), inclusive.—Fading of glasses containing arsenic, antimony, selenium, and combinations thereof; curve (1) represents original samples; curve (2), after sunlight exposure; curve (3), after ultraviolet exposure.

	Addition	Thickness (mm.)
(*A*)	As_2O_3 0.5	2.96
(*B*)	Sb_2O_3 0.5	3.22
(*C*)	Se 0.1	2.80
(*D*)	As_2O_3 0.5 + Se 0.1	2.91
(*E*)	Sb_2O_3 0.5 + Se 0.1	3.05

The exposure to sunlight and to ultraviolet light produced color changes which are shown in Fig. 1(*A*); this figure shows the percentage of light transmitted by the samples over the spectral range* from 400 to 700 mμ. Curve (1) shows the spectral transmission of the original sample; curve (2), the transmission after exposure to sunlight; and curve (3), the great reduction in transmission for short wave lengths of light which was produced after the sample was exposed to ultraviolet light.

Figure 1 (*B*) gives similar curves in a glass to which 0.01 part of iron oxide was added; this small amount of iron oxide showed a pronounced effect in decreasing the tendency to fade. In Fig. 1 (*C*), the glass contained approximately 0.02 part of iron oxide; in this glass as well as that shown in Fig. 1 (*D*), the exposure to sunlight increased the transmission of the longer spectral region. Figure 1 (*E*) shows that sunlight and ultraviolet light had nearly the same effect in producing fading in a glass which contains about 0.04% of iron oxide, and Fig. 1 (*F*) indicates that sunlight had even a slightly greater effect than ultraviolet light in a glass which contains about 0.06% of iron oxide.

The series of transmission curves given in Fig. 1, (*A*) through (*F*), shows that increasing amounts of iron oxide up to 0.06% reduced the fading, which was caused by exposure to ultraviolet light in this arsenic-bearing glass. Inasmuch as sunlight produced the reverse effect, namely, an increase in fading tendency, caution must obviously be used in correlating the fading of glassware which is subjected to ultraviolet light to the fading which might result during practical usage of the ware.

V. Fading of Glasses Containing Manganese and Arsenic Oxides

To the standard soda-lime-silica glass batch, 0.5 gm. of As_2O_3 and 0.25 gm. of MnO_2 were added. The transmission curve shown at the top of Fig. 2 (*A*) indicates a nearly colorless glass. Exposure to sunlight produced a tint (shown by curve 2 in Fig. 2 (*A*)) which was greatly intensified in the sample exposed to ultraviolet light (bottom line in Fig. 2 (*A*)). For comparison, the transmission of a glass containing 0.25 gm. of MnO_2, which was melted from a batch containing soda niter, is given in Fig. 2 (*B*). The different wave lengths of maximum absorption of the two glasses indicates a fundamental difference in the case of the metastable manganese-arsenic color and of the stable manganese purple. The first is easily changed by heat, whereas the latter is stable.

VI. Fading of Glasses Containing Arsenic, Antimony, and Selenium

Using the same procedure as in the foregoing tests, a comparison was made of the fading tendencies of glasses containing arsenic, antimony, or selenium. Figure 3 (*A*) shows the fading of the soda-lime-silica glass containing an addition of 0.5 part of As_2O_3, and Fig. 3 (*B*) indicates the much smaller fading of a corresponding antimony-bearing glass. Figure 3 (*C*) gives the results of fading tests on a glass sample to which 0.1 part of selenium had been added. Figure 3, (*D*) and (*E*), provides a comparison of the fading of the arsenic-selenium couple with that of the antimony-selenium combination.

VII. Discussion

The change in color which occurs when certain glasses are exposed to various types of radiation may be explained in several ways, most of which involve assumptions. In the case of the low-iron glasses used for ultraviolet transmission, the decrease in transmission after exposure to light has been proved by chemical analysis to be due to the oxidation of ferrous to ferric iron.[6] It has been suggested that the dissolved oxygen in the glass[7] may be the source of oxygen necessary for this conversion. When other coloring materials are present in the glass, the photochemical reactions are difficult to prove. For example, all of the higher oxides of manganese, cerium, arsenic, and antimony tend to oxidize ferrous iron in glass.[8] Thus the deep color of trivalent manganese does not usually exist when ferrous iron is present. Exposure to ultraviolet light tends to reverse the action of heat,[9] as illustrated by the chemical equation,

$$Fe'' + Mn''' \underset{\text{ultraviolet light}}{\overset{\text{heat}}{\rightleftharpoons}} Fe''' + Mn''.$$

The discoloration of such glasses, however, has been found to be accelerated[10] when the temperature of the glass is raised moderately (*ca.* 100°C.).

The discoloration of glasses containing iron and arsenic has been thought to be due to the ionization of ferrous arsenate,[11] which may exist in the glass, or to the formation of elemental arsenic.[12]

In the present studies, it was found that a soda-lime-silica glass melted in platinum from c.p. materials turned brownish after exposure to ultraviolet light. The discoloration of a glass containing intentional "impurities" must therefore be considered in connection with the possible changes which may have occurred in the parent glass. The color of an ion is influenced by the electrical field surrounding it, and this field may change markedly in glass after exposure to radiation.

* Colors corresponding roughly to these wave lengths are as follows: violet 400 mμ, blue 470 mμ, yellow 520 mμ, and red 700 mμ.

[6] D. Starkie and W. E. S. Turner, "Ultraviolet Light-Transmitting Glasses," *Jour. Soc. Glass Tech.*, **12**, 306–24T (1928).

[7] E. Zschimmer, "Decolorization and Discoloring of Glass," *Sprechsaal*, **59**, 93 (1926); *Ceram. Abs.*, **5** [12] 395 (1926).

[8] W. Weyl, "Chemistry of Colored Glass, I," *Glass Ind.*, **18** [3] 73–78 (1937); *Ceram. Abs.*, **16** [6] 170 (1937).

[9] P. Gilard and A. Lecrenier, "Influence of Various Radiations on Color of Glasses," *Chimie & industrie*, **24** [5] 1035–51 (1930); *Ceram. Abs.*, **10** [5] 331 (1931).

[10] C. L. Cross, "Color of Glass in Ultraviolet Light," *Phys. Rev.*, **II** [27] 108 (1926).

[11] E. J. Gooding and J. B. Murgatroyd, "Investigation of Selenium Decolorizing," *Jour. Soc. Glass Tech.*, **19** [73] 43–103T (1935); *Ceram. Abs.*, **15** [9] 215 (1935).

[12] J. Hoffmann, "Chemical Changes Caused in Glasses by Light and Heat," *Glastech. Ber.*, **13** [2] 47–52 (1935); *Ceram. Abs.*, **15** [7] 158 (1935).

Irradiation may cause an energy state in the glass which corresponds to the state at a higher temperature.[13] The new photochemical equilibrium is different from the normal thermal equilibrium inasmuch as energy has been added to the system. When the source of light is removed, the system tends to revert to its true equilibrium, and a gradual change is found in glasses which have been discolored by ultraviolet light and then allowed to remain in the dark for several months. This action is similar to the known effect of the bleaching of X-ray colorations by exposing the glass to ultraviolet light. The discoloration of some glasses after exposure to radium rays or to X rays has not been explained definitely although some evidence shows that the production of metallic uncharged atoms may be the cause.[14] The prevention of X-ray discoloration which is imparted to the glass by cerium may be due to the absorption of the X rays by this material with emission of the energy as fluorescent light. The prevention of ultraviolet discoloration by the addition of lead or of titanium oxides[15] to the glass, similarly, may be due to the marked absorption of such glasses, which confines the ultraviolet light to a thin surface layer of the glass.

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[13] A. Klemm and E. Berger, "Kinetics of Photochemical Change in Glasses by Ultraviolet Irradiation and Its Regeneration by Reheating," *Glastech. Ber.*, **13** [10] 349–68 (1935); *Ceram. Abs.*, **15** [4] 119 (1936).

[14] K. Przibram, "Discoloration and Luminescence by Becquerel Rays," *Z. Physik.*, **20**, 196 (1923–1924).

[15] B. Long, "Prevention of Color Development in Glasses by Exposure to Sunlight," Brit. Pat. 264,490, January 10, 1927; *Ceram. Abs.*, **6** [12] 585 (1927).

HEAT-OF-WETTING VALUES OF UNFIRED AND FIRED CLAYS*

By C. W. Parmelee and V. D. Fréchette

Abstract

The heats of wetting of unfired and fired clay minerals were measured on samples of montmorillonite, illite, and kaolinite types of clays. Autoclaved and unautoclaved samples of fired clays were studied. These data were obtained as a contribution to the knowledge of changes taking place in fired clayware through exposure to water vapor.

I. Introduction

The susceptibility of ceramic products to the attack of moisture can be determined in a number of ways. A rapid method of determining the heat-of-wetting values was desired as well as fundamental information regarding the nature of the attack. This need led to the present investigation of the heat of wetting of clays in the fired condition and of clays after an autoclaving treatment which was designed to simulate natural weathering in a shortened time.

The heat evolved when a solid substance is wetted by a liquid is a characteristic of both the solid and the liquid. In the case of clay minerals, it seems to be actually the heat of hydration of the available fraction of adsorbed cation,† that is, it is due to that residual ionic field which remains unsatisfied by the oxygen and hydroxyl groups at the mineral surface. This ionic field causes orientation of the liquid dipoles resulting in an evolution of heat which varies in amount directly as the dipole moment and inversely as the size of the liquid molecules.

With a single liquid, the heat of wetting of clays saturated with any one adsorbed ion is a linear function of the base-exchange capacity of the clays.†

Any change in the clay structure brought about by heat-treatment must be observed as a corresponding change in the heat of wetting of the product through its altered base-exchange capacity and through the rearrangement of the adsorbed ions.

What happens to the adsorbed ions during firing is not clear; they may form silicates. If these silicates are soluble, heats of considerable magnitude may be evolved on contact with water. Several clays and associated minerals release alkalis from their crystal structures on heat-treatment; this action may be expected of illite, beidellite, and micas over certain temperature ranges. Leaching of the fired products would remove the effects of these alkalis on the heat of wetting.

Any formation of clay minerals brought about by the treatment of fired clays in the autoclave through synthesis from the oxides, through kaolinization of the glassy phase, or through rehydration of the clay anhydrides should be indicated by a change in the heat of wetting of the autoclaved material as compared with the unautoclaved material.

The purpose of this study was to determine the changes in the heat of wetting as a result of firing and as a result also of subsequent autoclaving. The study is preliminary to a more complete investigation of the behavior of the adsorbed ions in the firing process and in moisture attack in service.

II. Review of Literature

The capacity of clays, which are fired at the lower temperatures (below 1050°C.), to take up water again

* Presented at the Forty-Second Annual Meeting, The American Ceramic Society, Toronto, Canada, April 9, 1940 (White Wares Division). Received June 25, 1941.

† C. G. Harman, Ph.D. Thesis, Department of Ceramic Engineering, University of Illinois, June, 1939.

has been pointed out by many investigators. Lemburg[1] heated lightly calcined kaolin with pure water for 318 hr. at 210° to 228°C., whereby all of the water was taken up again. Mellor and Holdcroft[2] treated kaolinite *in vacuo* at 600° to 640°C., and they were able to restore the water content to 4% by autoclaving.

Linck[3] succeeded in obtaining almost complete rehydration (11.44 to 12.95% of water) of kaolin, which had been dehydrated at 700°C., by autoclaving treatment at 15 atmospheres for 100 to 200 hr.

Schachtschabel,[4] who examined Linck's materials by X-ray diffraction methods, concluded that the product of low-temperature dehydration was an anhydride containing a little water. He reported,

> When the water content drops below 2 to 3 %, the lattice is destroyed so that only feeble diffraction patterns appear. . . . With this destruction of the lattice is associated closely the fact that the last 1 to 2% of water is very hard to drive off. . . . When water is added again, a lattice is formed very similar to the original kaolinite lattice, but with the lattice dimensions slightly smaller than in kaolinite.

Moore[5] concluded, " . . . if the firing temperature has not exceeded 900°C., part of the water lost from the clay on firing may be returned, to give a soft material. . . . "

Horning[6] found that a surface clay that was fired to any temperature below 900°C. and stored over water for a fortnight took up small quantities of water which could not be driven off at 110°C. and appeared, therefore, to be chemically combined.

Van Nieuwenburg and Pieters[6] measured the extent of rehydration of purified Zettlitz kaolin fired at temperatures between 420° and 1500°C. Rehydration was found to occur when the kaolin was stored for 48 hr. at 100 atmospheres, but the transformation was never complete. With temperatures below 950°C., it was 3.0%, and at 1100°C. it was 1.6%.

According to Barrett,[7] who worked with stoneware clay, shale, and surface clay, the extent of rehydration was greatest when the material was fired below 850° to 950°C., which is the range of firing shrinkage commencement. Rehydration showed a minimum in the range 950° to 1050°C. Between 1050° and 1150°C., another maximum in the rehydration curve appeared; above 1150°C., the curve fell off to a value close to that of the 950° to 1050°C. range.

In a review of the literature up to 1933 and especially of the work of Spangenburg and of Rhode and Schachtschabel, Jung[8] gives the following summary:

(1) Kaolin can be partially dehydrated without losing its structure, and the remaining water is distributed uniformly through the crystal. A kind of zeolitic water is thus obtained.

(2) By further dehydration, an amorphous product is formed which, on heating at about 550°C., will be transformed into a crystalline form known as alpha-kaolin ($Al_2O_3 \cdot 2SiO_2$).

(3) With rehydration as described by Schachtschabel, the time element is important whether the preceding dehydration took place partially or almost entirely. In the first case, the water can be taken up again into the remaining crystal lattice; in the second case, one or perhaps several hydrous aluminosilicates are formed. which can be converted to kaolin by suitable treatment.

According to Purdy and Moore,[9] the rehydration of clay fired above 625°C. is explained by the presence of salts that are either nonvolatile or are present in such a condition as to remain stable after firing. These authors state,

> They may be retained in loose combination with the dehydrated silicates of alumina, which can be broken down under the influence of water, and both the salt and the kaolin rehydrated. . . . It is not uncommon to find soft-fired brick and drain tile slaking down to a plastic mass.

The possibility that the observed hydration is the actual re-formation of clay minerals is shown by the fact that several investigators have succeeded in synthesizing the clay minerals by treatment of the oxides with water at elevated temperatures and in the presence of catalysts. Noll[10] treated Al_2O_3 and SiO_2 at 300°C. and 87 atmospheres of steam pressure in the presence of 0.1 *N* sodium hydroxide, and he was able to synthesize montmorillonite, which he identified by X-ray and petrographic methods. Ewell and Insley[11] synthesized kaolinite, dickite, beidellite, and nontronite by treating alumina and silica (both co-precipitated and mixed) with steam at 310° to 350°C. The products were identified by examination with the petrographic microscope and by X-ray diffraction.

The effects of this rehydration of the fired clays are evidenced by (1) the decomposition of the bond and crystalline phases and (2) the setting up of stresses which are the result of the hygroscopic nature of the

[1] J. Lemburg, "Formation and Inversions in Silicates," *Z. deut. geol. Ges.*, **40** [4] 625–56 (1888); p. 649.

[2] J. W. Mellor and A. D. Holdcroft, "Chemical Constitution of the Kaolinite Molecule, VII," *Trans. Ceram. Soc.* [England], **10–11**, 94–120 (1911).

[3] G. Linck, "Mineralogical Constitution of Clays," *Chem. Erde*, **3**, 370–74 (1927); *Ceram. Abs.*, **7** [12] 869 (1928).

[4] P. Schachtschabel, "Dehydration and Rehydration of Kaolin," *Chem. Erde*, **4**, 395–419 (1930); *Ceram. Abs.*, **10** [7] 524 (1931).

[5] C. E. Moore, "Plasticity of Clay," *Claycraft*, **6**, 381 (1930); *Ceram. Age*, **15** [4] 217–19 (1930); *Ceram. Abs.*, **9** [12] 1095 (1930).

[6] R. A. Horning, Thesis, University of Illinois, 1914.

[6] C. J. Van Nieuwenburg and H. A. Pieters, "Studies on Hydrated Aluminum Silicates: I, Rehydration of Metakaolin and Synthesis of Kaolin," *Rec. trav. chim.*, **48**, 27–36 (1929); *Ceram. Abs.*, **8** [8] 605 (1929).

[7] L. R. Barrett, "Rehydration of Fired Brick Clays," *Trans. Ceram. Soc.* [England], **36** [4] 201–16 (1937); *Ceram. Abs.*, **17** [2] 68 (1938).

[8] H. Jung, "Chemicophysical Processes During Dehydration and Rehydration of Kaolin Crystals," *Chem. Erde*, **7**, 113–20 (1932); *Ceram. Abs.*, **11** [12] 637 (1932).

[9] R. C. Purdy and J. K. Moore, "Pyro-Chemical and Physical Behavior of Clays," *Trans. Amer. Ceram. Soc.*, **9**, 204–30 (1907).

[10] W. Noll, "Synthesis of Montmorillonite," *Naturwissenschaften*, **23**, 197 (1935); abstracted from *Chem. Erde*, **10** [2] 129–54 (1936) in *Ceram. Abs.*, **16** [3] 99 (1937).

[11] R. H. Ewell and Herbert Insley, "Hydrothermal Synthesis of Kaolinite, Dickite, Beidellite, and Nontronite," *Jour. Research Nat. Bur. Standards*, **15** [2] 173–86 (1935); R.P. 819; *Ceram. Abs.*, **14** [11] 290 (1935).

rehydrated materials. Of these stresses, McBain and Ferguson[12] state, "The strains due to fluctuating humidity are often five times as great as others set up in building materials."

In experiments on the resistance of brick to freezing by immersion, Esse[13] found that the decrease in strength was not due to the action of frost but to the attack of water. The decrease in strength was approximately 19.3 to 33.2% at the end of 28 days.

[12] J. W. McBain and John Ferguson, "Nature of Influence of Humidity Changes on Composition of Building Materials," *Jour. Phys. Chem.*, **31** [4] 562–94 (1927); p. 564; *Ceram. Abs.*, **6** [6] 221 (1927).

[13] Esse, "Effect of Frost and Humidity on Resistance to Pressure of Paving Brick," *Tonind.-Ztg.*, **60** [35] 441–42; [36] 457–58 (1936); *Ceram. Abs.*, **16** [1] 19 (1937).

III. Experimental

(1) Materials

(*A*) *Montmorillonite Clay:* Montmorillonite is common to the wind-borne deposits of the loess type. It is found in many of the northern tier of states west of the Mississippi and in the western provinces of Canada. The sample used in this investigation was a commercial bentonite from Wyoming.

(*B*) *Illite Clay:* Illite is a common constituent of the shales which are widely used in the manufacture of clay products. The sample was provided through the kindness of R. E. Grim of the Illinois State Geological Survey.

TABLE I

HEAT-OF-WETTING VALUES OF KAOLINITE CLAY (CAL./GM.)

	Dried at (°C.)									
	110	400	600	700	805	875	925	1000	1080	1200
					Unautoclaved					
	1.8	1.1	1.4	1.2	1.1	0.86	0.74	0.60	0.46	0.19
	1.9	1.7	1.2	1.5	1.0	0.92	0.63	0.66	0.44	0.18
	1.8		1.7	1.4	1.1	0.94		0.60	0.51	
	1.8		1.3						0.51	
	1.9		1.3							
	2.1		1.5							
	2.0		1.7							
	2.0		1.5							
	2.2									
Avg.	1.9	1.4	1.4	1.4	1.1	0.9	0.7	0.6	0.5	0.2
					Autoclaved					
		1.3	1.4	1.6	1.5	1.2	0.75	0.57	0.45	0.16
		1.2	1.3	1.4	1.4	1.2	0.67	0.59	0.49	0.14
		1.3	1.4	1.5						0.18
			1.4	1.2						
			1.6							
Avg.		1.3	1.4	1.4	1.5	1.2	0.7	0.6	0.5	0.2

TABLE II

HEAT-OF-WETTING VALUES OF ILLITE AND MONTMORILLONITE CLAYS (CAL./GM.)

	Dried at (°C.)								
	110	450	500	700	805	875	925	1000	1080
					Montmorillonite				
					(Unautoclaved)				
	11.8	11.0	7.9	3.4	0.49	0.20	0.36	0.19	0.13
	11.7	11.4	8.3	3.1	0.52	0.40	0.29	0.24	0.16
	11.8	8.4	8.0	3.1	0.65				
Avg.	11.8	10.3	8.1	3.2	0.5	0.3	0.3	0.2	0.1
					(Autoclaved)				
		10.4	8.6	4.7	0.77	0.34	0.43	0.14	0.21
		11.5	8.2	4.7	0.72		0.12	0.12	0.21
				4.6					
Avg.		11.0	8.4	4.7	0.7	0.3	0.3	0.1	0.2
					Illite				
					(Unautoclaved)				
	4.3	5.0	5.3	3.6	0.67	0.27	0.24	0.21	0.22
	4.0	5.6	5.1	3.3	0.68	0.27	0.23	0.25	0.20
	3.6	5.3							
Avg.	4.0	5.3	5.2	3.5	0.7	0.3	0.2	0.2	0.2
					(Autoclaved)				
		4.4	4.3	3.5	0.82	0.25	0.21	0.07	0.17
		4.8	4.3	3.5	0.98	0.28	0.41	0.03	0.16
		5.0	4.2						
Avg.		4.7	4.3	3.5	0.9	0.3	0.3	0.05	0.2

(*C*) *Kaolinite Clay:* Kaolinite forms the principal part of the plastic fire clays, some of which are used for structural clay products. The sample used was obtained from North Carolina.

(2) Firing and Autoclaving

The firing was carried out in a large electric furnace which operated under automatic potentiometer control. Samples of the powdered clays contained in 50-cc. unglazed porcelain crucibles were set in the hot furnace; after 7 hr., they were removed and cooled over 95% sulfuric acid. One half of each of these samples, which were prepared at temperatures covering the range 400° to 1200°C., was autoclaved before the measurement of its heat of wetting. The heat-of-wetting values for the rest of the samples were taken without autoclaving.

The powdered materials contained in platinum crucibles were autoclaved at a steam pressure of 150 lb. per sq. in. which was maintained for 4 hr.

(3) Heat-of-Wetting Measurements

The materials for the heat-of-wetting measurements were first pulverized to pass a 40-mesh sieve and heated at 110°C. for 8 hr. in weighing bottles holding approximately 40 gm. of clay. The bottles were tightly stoppered, cooled over sulfuric acid, weighed, and sealed about the rim with paraffin to prevent access of moisture.

The calorimeter in which the heat of wetting was measured consisted of a 900-ml. Dewar flask mounted in an upright plaster of Paris shape. The flask was fitted with an insulated cover through which were admitted a Beckmann thermometer and a glass rod bearing a ladle-shaped stirrer of perforated copper. The stirrer parts were joined together and coated thinly with beeswax, which was the only inert substance of those that were tried that did not dissolve or suffer abrasion with use. A mechanical drive moved the stirrer up and down at the rate of 80 strokes per minute to effect thorough mixing without developing excessive heat by friction.

For the heat-of-wetting measurement, the sample bottle was suspended in the calorimeter with 300 ml. of water together with the stirrer and thermometer. A period of 12 hr. was allowed for the sample, the water, and the calorimeter parts to come to the same temperature; the stirring was begun, and temperatures were recorded to $^1/_{1000}$ degree each minute. After 15 minutes had elapsed to establish the temperature-time gradient, the sample was poured into the water, and the reading was continued for 15 minutes longer.

The water equivalent of the calorimeter was determined by passing a measured electric current through a small Chromel resistance coil immersed in the water of the calorimeter. The temperature rise of the calorimeter was then calculated by extrapolating the time-temperature curve obtained before releasing the sample to a point in time where the slope of the observed curve, following the wetting of the clay, had become constant again. The temperature difference between the curves at this point multiplied by the water equivalent of the calorimeter and sample was taken as the heat of wetting of the whole sample, whose weight was then used to express the result in calories per gram of material.

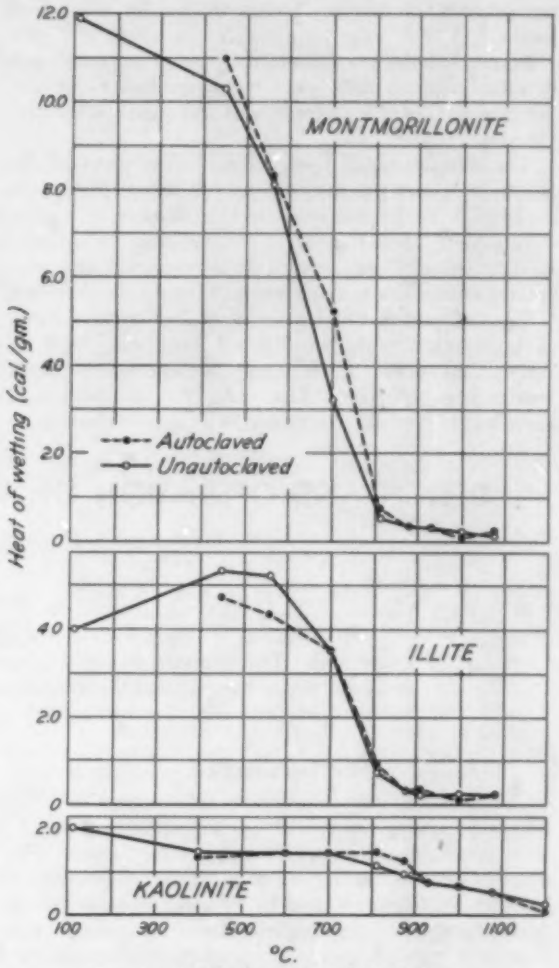

FIG. 1.—Heat of wetting of fired clays.

IV. Discussion of Results

Tables I and II give the values of individual measurements and the mean. The variation from the means are attributable to several factors such as (1) the limitations of the Beckmann thermometer for measuring the very small temperature rises in the calorimeter, (2) the difficulty of drying the samples uniformly, and (3) the thermal leakages in the calorimeter occasioned by water evaporation, by fluctuations in the room temperature, and by air currents. A more elaborate system of calorimetry and drying technique is necessary for increased precision.

The data given in Tables I and II are useful to establish the magnitudes of the heat of wetting to be expected and to show the general trends of these values in fired clays and in fired clays that have been autoclaved.

The three clays, in the unfired state, show a wide range of heats of wetting, from the low value of 1.9 cal.

per gm. for the primary kaolin to 11.8 for montmorillonite.

Figure 1 shows graphically the heat-of-wetting values of a kaolinite, an illite, and a montmorillonite clay after various degrees of heat-treatment and, again, after autoclaving.

The significance of these values lies in the fact that the heat of wetting may be an indication of the susceptibility of the specimen to destruction by contact with water. A high heat of wetting may be expected to indicate abnormally high capillary forces and great strains within the ware as a result of varying humidity.

The two curves, which give the heat-of-wetting values of unautoclaved and autoclaved materials, show the course that surface activity may be expected to take as weathering progfesses. The value for the autoclaved sample is higher in some cases than that for the unautoclaved. The mechanism of the increase in the heat of wetting with moisture attack is not clear. Whether it is through the formation of clay minerals or through the release of cations from initially nonionized compounds, it must result in increased strains within the clayware during wetting and drying as weathering progresses. The reverse situation in which the heat-of-wetting value for the autoclaved material is lower may possibly be explained by postulating the binding of adsorbed cations to form nonionized compounds. Such materials will doubtless become less sensitive to moisture as a result of moisture attack.

Further study of the heat of wetting with more refined calorimetry and sample-drying technique should add to the understanding of the weathering problem.

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DESIGN AND OPERATION OF AN ELECTRIC LOAD-TEST FURNACE*

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Abstract

The construction and operation of a high-temperature electric load-test furnace are described. Temperatures to 1900°C. can be obtained with a spiral graphite heating element which has reasonable voltage and current characteristics. Neither a vacuum nor a special atmosphere is used inside the furnaces. Life and operating data are given.

I. Introduction

One phase of the program of the Bureau of Mines Electrotechnical Laboratory is the development of a basic forsterite refractory by the electric furnace treatment of olivine. Standard 9-in. brick are being made both by electrocasting and by hydraulic pressing methods. To make a thorough study of the products obtained, it has been necessary to design and build electric furnaces for conducting the various A.S.T.M. and special tests at temperatures higher than that of the ordinary electric furnace for molded-product heating.

Many types of electric furnaces have been designed and used for special applications. Carbon-granule furnaces, such as P.C.E. and muffle furnaces, are well known. Solid carbon is used in many forms, including solid rods, hollow cylinders, grids, and the Arsem spiral. The indirect arc is used for special applications, and carbon is used as the susceptor for high-frequency induction furnaces. The recrystallized silicon carbide heating element has wide application within its temperature limit.[2] Tungsten and molybdenum[3] are used for high-temperature furnaces under special conditions and platinum is used for an oxidizing atmosphere[4] to cone 20. The temperature range, the ease of control, and the quiet operation of the electric furnace make it desirable for many types of investigations.

II. Furnace Design

Of these types mentioned, the carbon-element furnace appears to be the most desirable for conducting load tests of full-size refractory brick. Artificial graphite is widely used and has many desirable characteristics for high-temperature work. It is the most refractory material known, a good thermal conductor, load resistant at high temperatures, slag resistant, and easily machined into special shapes. The cost of artificial graphite ranges from $6 per 100 lb. for scrap pieces to $14 per 100 lb. for full-length plain electrodes.

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[1] (*a*) A. Coggleshall and A. V. Bleininger, "Convenient Carbon-Resistance Furnace," *Trans. Amer. Ceram. Soc.*, **10**, 54–60 (1908).

(*b*) M. M. Austin, "Granular Carbon Resistor Furnace," *Ind. Eng. Chem.*, **16** [2] 156 (1924); *Ceram. Abs.*, **3** [5] 132 (1924).

(*c*) W. L. Pendergast, "Electric Furnace for Softening Point Determinations," *Jour. Amer. Ceram. Soc.*, **8** [5] 319–25 (1925).

(*d*) W. L. Pendergast, "Electric Furnace for Determination of Pyrometric Cone Equivalents," *Bull. Amer. Ceram. Soc.*, **18** [1] 1–3 (1939).

[2] A.S.T.M. C16–39T, *A.S.T.M. Standards*, Pt. 2, p. 160 (1939).

[3] Louis Navias, "Welded Zigzag Windings and Refractory Shapes for High-Temperature Furnaces," *Jour. Amer. Ceram. Soc.*, **14** [5] 365–75 (1931).

[4] Edward Orton, Jr., and J. F. Krehbiel, "Convenient Platinum-Wound Resistance Furnace," *ibid.*, **10** [5] 373–87 (1927).

The chief disadvantages of carbon are an affinity for oxygen above red heat and the production of a reducing atmosphere, which in many cases is not wanted.

Several furnace designs were considered. A furnace which consisted of a chamber heated directly or indirectly by several small arcs was eliminated because of the difficulty in maintaining uniform heating and because of the extreme temperature gradient between the arc and the furnace chamber. A carbon-granule furnace was considered undesirable because of its uneven heating and the maintenance of muffle tubes. Small rods might be used as the elements, but they would have a high total current demand if several were used in parallel or, if fewer rods were used, they would have a very high current density per rod and would produce uneven heating. A grid-type furnace consisting of graphite slabs with slots cut on alternate sides to form a long current path could be designed which would give a reasonable current-voltage characteristic and uniform heating, but it would introduce a number of construction difficulties.

It was finally decided to use a modification of the Arsem-type furnace.[5] A spiral element can be designed for a rather wide transformer range and can be machined with ordinary shop equipment. As a furnace for testing full-size specimens under load does not lend itself well to operation either under vacuum or with a special atmosphere, it was necessary to make a design that would avoid the infiltration of air as much as possible.

Figure 1 shows a cross-section view of the assembled parts. The whole furnace (except the top) is enclosed in a lightweight sheet-iron shell, which is lined with high-grade insulating firebrick. An annular space about $1\frac{1}{2}$ in. thick is filled with finely crushed graphite, which is insulated from the top terminal block by $\frac{1}{2}$ in. of alumina powder; inside this space is a graphite cylindrical sleeve that rests on the bottom terminal block and extends to within $\frac{3}{16}$ in. of the top terminal block. The spiral heating element is turned on the lathe with a slot $\frac{1}{2}$ in. wide and a collar on top, which seats into the top terminal block. Electrical connection is made with the bottom block by means of a slip joint. An inside protecting sleeve is made in two sections which are separated to avoid a short circuit; the bottom piece fits loosely into an annular ring in the bottom block, and the top section has a collar that fits into the heating element. A square hole is left in the brick covering the top of the furnace. Inside the hole a graphite plate is loosely placed in which holes are cut for the load member and the observation hole. This plate helps to protect the inside of the furnace from oxidation, provides easy access to the inside sleeve and heating element, and helps to protect the cover brick from direct heat radiation.

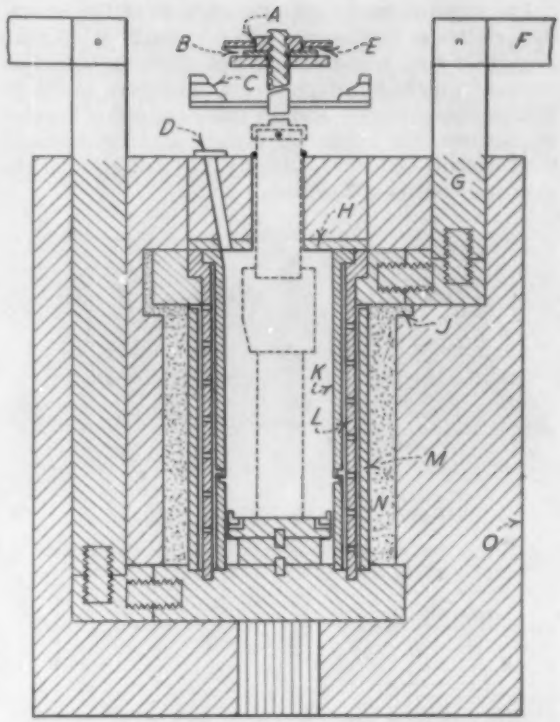

FIG. 1.—Section through load-test furnace; *A*, safety catch; *B*, micrometer dial; *C*, weight pan; *D*, pyrometer opening; *E*, expansion indicator; *F*, electrical connection; *G*, graphite terminal; *H*, oxygen filter plate; *J*, alumina powder; *K*, inside sleeve; *L*, heating element; *M*, outside sleeve; *N*, fine carbon; *O*, steel shell.

A removable graphite pedestal fits on the bottom block; it may be made in the form of a cup to be used when a specimen is in danger of melting. Holes are drilled in the sides to allow removal of the pedestal with a pair of tongs. The bottom terminal block is supported by silicon carbide brick to carry the load applied to the specimen. Lead weights placed on a pan, which is keyed to the vertical pressure shaft, supply the load of 25 lb. per sq. in. to the sample. A pure silicon carbide brick is suspended from a socket at the bottom of the shaft and bears on a graphite block placed on the specimen. A threaded collar with four radial arms and a thrust bearing serve as an easy means to raise or adjust the load and as a safety catch when a specimen fails by shear or sudden slump. The load-bearing shaft is made in two sections held together during operation by a slotted sleeve and forked key.

Figure 2 shows the graphite parts used in the furnace. In the background from left to right are the top terminal block, the spiral element with the collar shown at the bottom, the outside cylindrical sleeve, and the bottom terminal block.

Addendum: In the latest design, the brick beneath the top terminal block are extended to give a solid ring support for the block (see Fig. 1), which is an improvement over that of the three-stud support (see top terminal block, Fig. 2). This change in design simplifies fabrication, lessens strains in the top block, and gives a longer operating life.

[5] (*a*) W. C. Arsem, "The Electric Vacuum Furnace," *Trans. Amer. Electrochem. Soc.*, **9**, 153–72 (1906).
(*b*) C. W. Kanolt, "Melting Points of Refractory Materials," *Trans. Amer. Ceram. Soc.*, **15**, 167–76 (1913); p. 169.
(*c*) C. O. Fairchild and M. F. Peters, "Characteristics of Pyrometric Cones," *Jour. Amer. Ceram. Soc.*, **9** [11] 701–43 (1926); pp. 709–10.

The spiral elements were designed to fit the laboratory electrical equipment, which consists of 40-kva., 220/24–32-volt transformers, and 220-volt induction voltage regulators. Stepless control between 15 and 36 volts is thus provided, and, by using one coil of another transformer, the maximum voltage may be increased to 52 volts if necessary. Figure 3 is a diagram of the electrical-control connections.

FIG. 2.—Graphite parts in furnace.

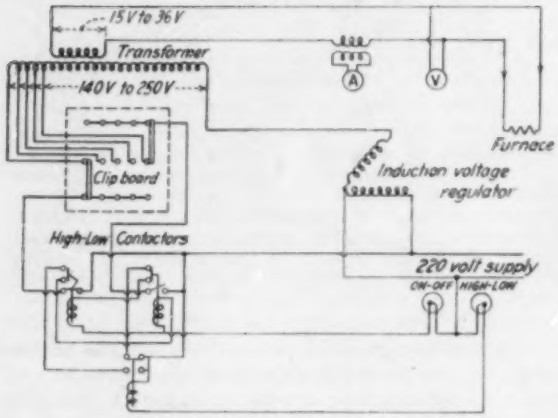

FIG. 3.—Control connections.

III. Measuring Instruments

Two methods have been used to determine linear changes of the specimens. The manual method is shown in Fig. 4. An adjustable pointer is attached to the threaded collar, beneath which is a stationary dial graduated clockwise and counterclockwise in thousandths of an inch and covering a total movement of 0.25 in. The pointer is set at zero at the beginning of each run, with the collar turned snugly against the bearing plate. Upward or downward movements for expansion and shrinkage, respectively, are read directly at any time by lowering the collar until it is snug. The collar is raised to a loose position between readings.

The second, or recording method of determining linear changes, is shown in Fig. 5, which also pictures the furnace, voltage regulator, and optical pyrometer. A lever arm giving a 10 to 1 magnification is attached to the top of the vertical pressure shaft. A removable pin allows the arm to be disengaged when loading and unloading the furnace. An electrically driven drum, a recording pen, and a mimeographed chart complete the mechanism (as shown in Fig. 6). Linear changes are

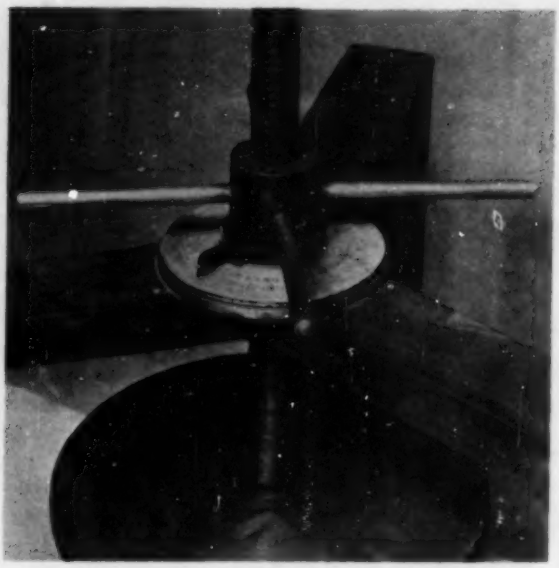

FIG. 4.—Linear change indicator; plate for holding lead weights below.

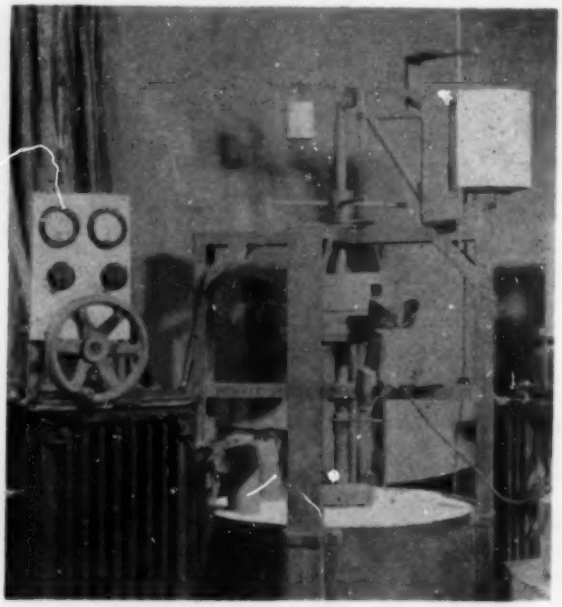

FIG. 5.—Furnace, voltage regulator, and automatic linear change recorder.

automatically recorded against time, and the temperature curve may be plotted manually on the same chart.

The laboratory is now operating two such furnaces. The only essential difference is the inside diameter. The first furnace has a diameter of 6 in.; that of the second was increased to $7^1/_2$ in. to fire two brick simultaneously without load or one with load. When firing without load, the linear changes are observed by placing a small silicon carbide rod on top of the brick and

noting the movement of the exposed end with an Ames dial gauge or cathetometer.

A platinum-platinum rhodium thermocouple inside an alumina target tube is used to measure the temperature up to about 1000°C.; a potentiometer-type optical pyrometer is then sighted on the bottom of the target tube to its temperature limit, and the extremely high temperature readings are obtained by sighting the optical pyrometer directly on the specimen through the observation hole. The target tubes now in use are satisfactory to about 1650°C., which covers the range of many samples being tested.

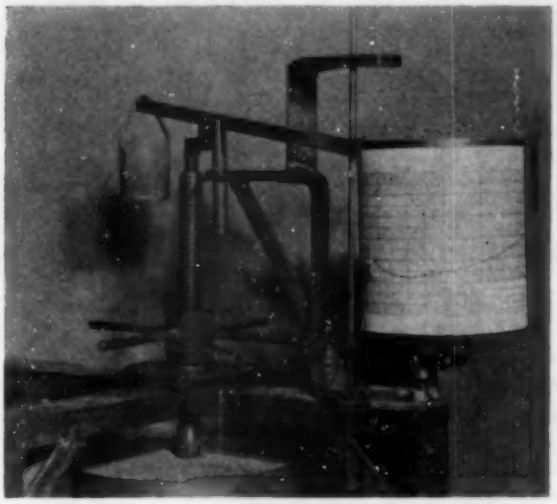

FIG. 6.—Linear change recorder on load-test furnace.

IV. Calibration

Figure 7 shows expansion curves for the 6-, 9-, and 12-hour heating cycles of furnace No. 1 and gives the method of calibration with a pure self-bonded silicon carbide brick. The data indicate a constant expansion lag in the 6-hr. test compared to the results of the 9- and 12-hr. tests. The maximum difference at 1700° C., however, is only 0.013 in., or 0.14% of the length of a standard 9-in. brick.

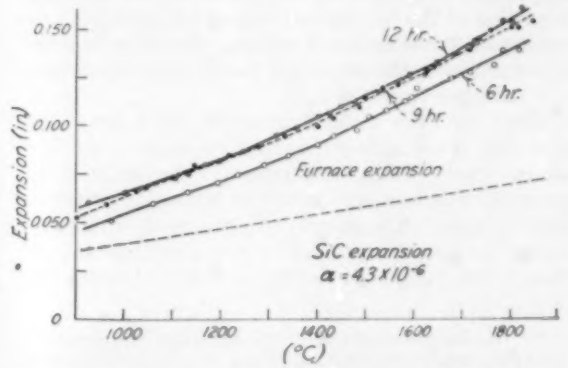

FIG. 7.—Calibration curves for load-test furnace No. 1.

V. Operation

Figure 8 is the graph of a load-test run and shows temperature, total expansion, calculated specimen expansion, and power input against time. Table I gives data from nine tests, showing the length of time of the test and the maximum temperature reached for various samples under 25 lb. per sq. in.

TABLE I

LOAD-TEST FURNACE DATA

Test No.	Time Hr.	Time Min.	Maximum temp. (°C.)	Sample
8	8	34	1800	Electrocast forsterite
14–2	7	40	1930*	Commercial electrocast
25	4	20	1436	" magnesia
27	7	56	1596	" silica
42	6	9	1391	" chrome
46	7	30	1769	Pressed forsterite
55	7	17	1763	Commercial electrocast
65	6	45	1678*	Pressed kyanite
76	6	45	1700*	" forsterite

* Carried beyond maximum expansion but not to failure.

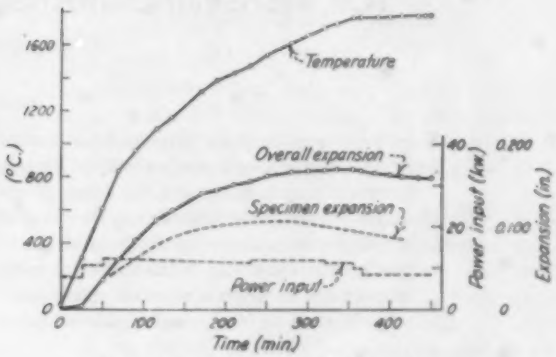

FIG. 8.—High-temperature load test operating characteristics.

In these tests, the temperature may follow A.S.T.M. heating schedules or more rapid rates for special samples or the most resistant refractories. From about 50°C. below the maximum expansion, the temperature is increased slowly; the rise continues until the specimen fails or shows $^1/_4$-in. shrinkage from the original length.

VI. Summary

Failures of the spiral elements have been due to oxidation, to sealing in or flooding from the sudden melting of fluid basic specimens, and to breakage from handling when repairs are made or designs changed. Failures of the removable protection plate, top block, and inside top sleeve are caused by gradual oxidation. "Power-on" lives of 50 to 100 hr. for the removable plate, of 200 to 300 hr. for the top terminal block, of 250 to 300 hr. for the inside top sleeve, and of 200 to 250 hr. for the element seem reasonable at present. The remaining parts are sufficiently protected from oxidation to last indefinitely.

Some advantages of this type of furnace are as follows: (1) a maximum operating temperature of

1800°C., with present fire-clay insulation or higher with better refractories; (2) ease of control, low heat radiation, no exhaust-stack gas loss, and quiet operation; (3) closeness of observation and convenient location of instruments; (4) very rapid heating if desired; (5) uniform heating if the heating chamber is of sufficient length; (6) use of graphite for load block and pedestal, avoiding high-temperature chemical attack on the specimen and sticking of samples on removal; (7) ease and accuracy with which expansion and shrinkage may be determined; and (8) a reducing atmosphere for testing refractories that will be used under reducing conditions.

The chief disadvantages of such a furnace are (1) difficulty in obtaining accurate temperature readings without the protection tube in the very high range because of flame and smoke (this is probably true, however, of any high-temperature furnace not operating in a vacuum or inert atmosphere; the difficulty is partly overcome by blowing a small jet of air across the top of the observation hole while a reading is taken); (2) a reducing atmosphere for testing certain refractories that will be used under oxidizing atmosphere (comparative tests are being made to determine the difference, if any, on some types); and (3) frequent overhauling; repairs should be less frequent and easier, however, as further improvements are made in design and operating technique.

Acknowledgment

The authors wish to acknowledge the valuable assistance of Earl F. Nichols of the laboratory staff in the design and construction of the furnaces.

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USE OF THE PHOTRONIC CELL AND SPECTROPHOTOMETER FOR MEASURING TRANSLUCENCY OF WHITEWARE*

By Frank C. Arrance

Abstract

A method has been developed for measuring the translucency of whiteware by means of the photronic cell, and a modified formula has been derived to express the relationship between translucency and thickness of ware. Bodies containing mixtures of feldspar and lepidolite were translucent over a greater range of temperatures than those which contained feldspar or lepidolite alone, although the translucency of the feldspar bodies was greater than that of the lepidolite bodies having equivalent absorptions. The spectrophotometer gives a more complete record of the translucency of porcelain because it may be used to measure the transmittance of ultraviolet, visible, and infrared light.

I. Introduction

The translucency of whiteware is important because it is probably used more than any other property to classify and judge the quality of dinnerware. The high translucency of china and porcelain distinguishes this ware from the opaque earthenware or semivitreous dinnerware. Translucent ware in general seldom develops delayed crazing, whereas opaque, less vitreous ware often crazes after several years of service. High translucency, therefore, is an indication that ware probably will not craze in service.

Translucency may be defined as the percentage of incident light which passes through a body. Many different factors affect the passage of light through ceramic bodies, namely, (1) the reflection and diffusion of light, (2) the shape of suspended particles, and (3) the relative indices of refraction of the matrix and suspended materials.

When light is reflected from the surface, the amount passing through the surface is reduced and the translucency is lowered. Surface reflection may be increased by raising the average index of refraction of the minerals in the body or by making the surface rough.

The amount of light which passes through a body also depends on the internal reflection or diffusive power of the body as well as on the absorption of light by the body, which is increased by minerals with a high coefficient of light absorption. The diffusive power is raised by increasing the number of suspended particles in the matrix, by particles which have an irregular shape, and by increasing the differences in indices of refraction of the matrix and suspended particles. According to Parmelee and Ketchum,[1] the diffusive power is greatest when the suspended particles are equal to one half the wave length of light.

There are a few ceramic materials which are porous as well as translucent owing to the opacifying power of air in pores. These properties are the result of the great difference in the indices of refraction of the air and the solid. The opacity of powders of transparent material may be explained in a similar manner. Although fused alumina crucibles are highly porous, they

* Presented at the Forty-Third Annual Meeting, The American Ceramic Society, Baltimore, Md., April 2, 1941 (White Wares Division). Received September 10, 1941.

[1] C. W. Parmelee and P. W. Ketchum, "Investigation of Translucency of Porcelains," *Univ. of Illinois Eng. Expt. Sta. Bull.*, No. 154, p. 13 (1926).

are also translucent, probably due to the large size of the individual particles and pores.

The high translucency of oiled paper is caused by oil in the pores which have an index of refraction nearer to that of the paper than that of air. In porcelain, the matrix is largely fused feldspar with an index of refraction close to that of quartz and, therefore, translucent. As the amount of suspended material is decreased and the glassy matrix is raised, the translucency is increased. Translucency measurements, therefore, may be used as an approximate method to determine the glass content in bodies.

Although the translucency of bodies may be roughly compared by examining the bodies in front of a bright light, there has been a demand for more accurate methods of measuring this property. Steger[2] used a photometer to determine the degree of translucency, and Parmelee and Ketchum[1] used an argon-filled photoelectric cell to measure this property.

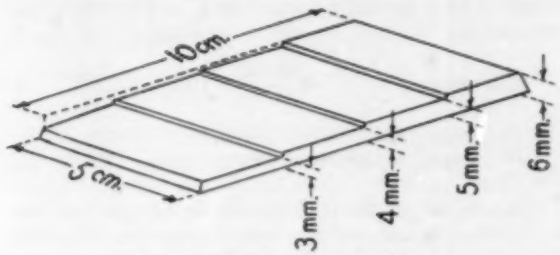

FIG. 1.—Translucency specimen.

It is important that the measuring devise be sensitive to small changes in light and that it should also register very weak sources of light. A photronic cell meets these requirements to a high degree. Part of the purpose of this work was to test the utility of this cell for determining the translucency of whiteware bodies. The results indicate that the photronic cell is adequate for this purpose except that it measures a certain amount of invisible light as well as the visible light passing through the ware. By using a special filter, however, only the visible light is measured. It is desirable in some cases to ascertain how much visible, ultraviolet, and infrared light has passed through the ware, and this value may be obtained with a spectrophotometer. The usefulness of the Coleman spectrophotometer, therefore, was studied as a means of ascertaining the translucency of whiteware to light of different wave lengths.

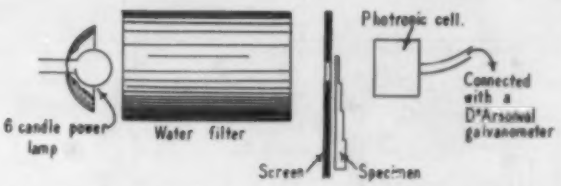

FIG. 2.—Method used to measure translucency of whiteware bodies.

II. Experimental Methods

(1) Photronic Cell

A vitreous hotel china body was used as a base in preparing bodies for this investigation (see Table I). Various mixtures of lepidolite and feldspar were used as fluxes, the total content of which varied from 10 to 25%.

Step-shaped wedges, similar to those used by Geller and Creamer,[3] were employed as specimens (see Fig. 1). They were molded in the plastic condition, dried, and the surface imperfections were removed with sandpaper. They were fired to cones Nos. 5, 7, 9, 11, and 12, and the thickness of the sections was measured with micrometer calipers.

[2] W. Steger, "Translucency of Porcelain," *Ber. deut. keram. Ges.*, **2**, 9–17, 63–66 (1921); *Ceram. Abs.*, **1** [12] 318 (1922).

[3] R. F. Geller and A. S. Creamer, "Effect of Feldspar in Pottery Bodies," *Jour. Amer. Ceram. Soc.*, **14** [1] 30–71 (1931); p. 45.

TABLE I

COMPOSITIONS AND ABSORPTIONS OF BODIES*

Body No.	(1) English ball clay (%)	(2) Fla. kaolin (%)	(3) English china clay (%)	(4) Potter's flint (%)	(5) Whiting (%)	(6) Lepidolite (%)	(7) Buckingham feldspar (%)	Absorption (%) at cone No. 5	7	9	11	12
A1	7.12	5.34	29.36	30.68	2.50	25.00	0	2.4	0.8	0	1.6	5.8
2	"	"	"	"	"	16.67	8.33	2.8	1.9	0.1	0.3	6.3
3	"	"	"	"	"	8.83	16.33	3.9	1.9	0	0.1	1.9
4	"	"	"	"	"	0	25.00	7.3	3.7	0.5	0.2	0
B1	7.61	5.71	31.38	32.80	"	20.00	0	5.1	3.2	0.3	0.2	3.6
2	"	"	"	"	"	13.34	6.67	4.1	3.3	0.3	0.1	1.8
3	"	"	"	"	"	6.67	13.34	6.5	3.8	0.3	0.2	0.5
4	"	"	"	"	"	0	20.00	8.6	4.9	0.8	0.1	0
C1	8.10	6.08	33.40	34.92	"	15.00	0	7.2	5.4	0.5	0.1	0.5
2	"	"	"	"	"	10.00	5.00	8.3	5.3	1.1	0.4	0
3	"	"	"	"	"	5.00	10.00	9.2	5.6	1.4	0.2	0
4	"	"	"	"	"	0	15.00	11.4	7.4	2.1	0.3	0
D1	8.59	6.44	35.43	37.04	"	10.00	0	11.3	8.1	3.2	1.7	1.2
2	"	"	"	"	"	6.67	3.33	11.4	7.3	1.8	0.1	0.4
3	"	"	"	"	"	3.33	6.67	12.5	8.7	3.0	0.4	0
4	"	"	"	"	"	0	10.00	13.9	11.4	3.7	0.7	0

* The body ingredients were supplied as follows: (1) Great Beam, (2) Edgar Plastic Kaolin Co.; (3) MGR-1; (4) Pennsylvania Pulverizing Co.; (5) Pure Calcium Products Co.; (6) Foote Mineral Co.; and (7) Consolidated Feldspar Co.

The apparatus used is shown in Figs. 2, 3, and 4.

The source of light was a lamp of 3- to 6-candle power, operated with a 6-volt storage battery. A parabolic reflector mounted behind the lamp reflected parallel light rays on the specimens. The light intensity was adjusted by means of rheostats of 6 and 30 ohms, mounted in series with the lamp and parallel with each other. The intensity of the light was adjusted so as to cause the photronic cell to register 36,380 microamperes on the galvanometer.

The radiant heat was removed from the light by means of a water cell, *F* (Fig. 3), which was a 3-in. brass-tube, 4 in. long with glass windows cemented in the ends. This water cell was filled with distilled water through a stoppered hole and was placed so that all light passed through it before striking the specimen.

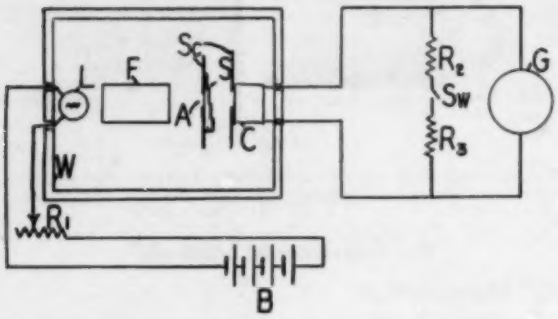

FIG. 3.—Circuit diagram of apparatus for measuring translucency of whiteware bodies; *L*, standard light (6 candle power); *F*, water filter; *A*, aperture for light; *S*, specimen; *C*, Weston photronic cell; R_1, variable resistance; R_2 and R_3, known resistance; *B*, battery (6 volts); *G*, d'Arsonval galvanometer; *Sw*, switch; *W*, wooden light-tight box; and *Sc*, screen.

A Weston photronic cell (*C*) was used to measure the light intensity. A screen with a $^1/_2$- by $1^3/_8$-in. opening was placed before the cell so that the light would strike the same portion of the cell each time. Another screen with a $^5/_8$- by $1^1/_2$-in. opening was placed between the specimen and the water cell so as to expose the same area of specimen to the light.

When the intensity of the light source was measured, the current generated by the cell was reduced because it was larger than the galvanometer scale would indicate. Resistances, R_2 and R_3 (Fig. 3), were used for this purpose. It was also necessary to reduce the current in a similar manner to measure the transmitted light through some of the more translucent specimens.

The translucency is expressed as the percentage of transmitted light in terms of the incident light; for example, the translucency of body A1, which was fired to cone 9 for a specimen 3 mm. thick, was calculated as follows:

$$\text{Translucency} = \frac{Tr}{I} = \frac{38.00}{36380} \times 100 = 0.1048. \quad (1)$$

Tr = transmitted light (microamp.).
I = incident light (microamp.).

The accuracy of the translucency determinations was ± 0.0002 microampere for repeat tests on the same specimens, and the thickness of the specimens was measured to an accuracy of ± 0.001 mm. with an Ames dial.

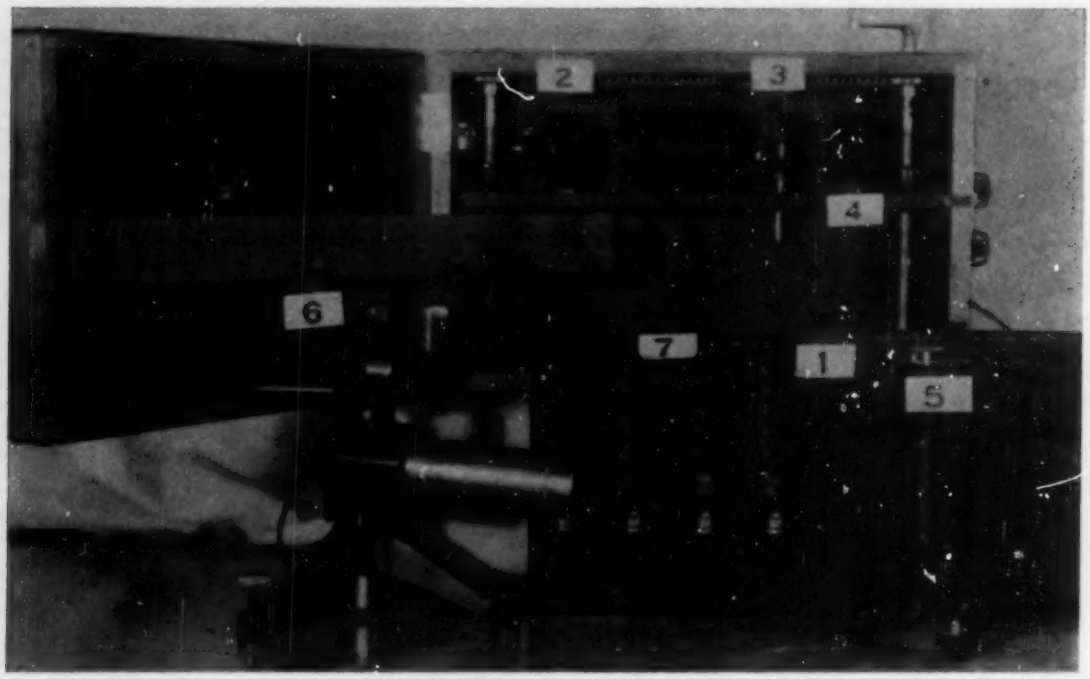

FIG. 4.—Photograph of apparatus.

(2) Spectrophotometer

A Coleman direct-reading spectrophotometer* was used in these tests. Thick specimens (4.0 mm.) as well as thin sections (0.5 to 1.5 mm.) were tested. Because of the small amount of light passing through such specimens, a means of measuring spectral transmission as low as 0.0005% was devised. This was accomplished by using the decade as a multiplier and by making the transmission measurements approximately 100 times the sensitivity of the standardization. With this method, 1% is the full scale of the potentiometer, and by using a Coleman model 4 potentiometer, the instrument may be read directly to 0.0005% and may be estimated to 0.0001%.

In testing sample A, for instance, the 100 decade may be assumed to be set at 1 and the electrometer reading obtained on the 60-mv. scale when making the transmission measurement to be 0.57 (considering the full 60-mv. scale to be 10% and the ratio for comparing the 1 position on the "100" decade with the 10 position on the "1000" decade to be 1.10 to 100). The actual percentage transmission is as follows:

$$\text{Reading } (\%)\ 1.10/1000 = 0.57. \qquad (2)$$
$$1.10/1000 = 0.00063\%.$$

The translucency of thin sections was measured with the regular Coleman spectrophotometer. The 0.5- to 1.5-mm. sections were cut with a diamond saw from bars, 1 by 1 in. Owing to the thinness of the slices, a few specimens contained small holes or other imperfections which were filled with flint. Their total area, however, was so small as compared with the area of the specimens that the error from this source was insignificant.

The transmission of light through the thick and thin specimens was measured at wave lengths which varied from 450 to 1000 mμ at intervals of 30 mμ.

III. Results and Discussion

The results obtained with the photronic cell are given in Tables II, III, and IV and have been plotted in Figs. 5, 6, 7, and 8, and the spectrophotometer results have been plotted in Fig. 9.

* Coleman Electric Co., Maywood, Ill.; measurements of the thicker specimens were made by the same company.

(1) Photronic Cell

The transmission of light through the wedge-shaped specimens varied from 0.2 to 108 microamperes, depending on the composition and thickness of the sections (see Table II). Only a small portion of the incident light (0.0006 to 0.297%) passed through the specimens (see Table III).

Figure 5 shows that the relation between translucency and thickness is not linear (as Ashley and Steger thought) but is exponential. This observation was also made by Parmelee and Ketchum.[1]

The relationship between translucency and thickness (for thicknesses between 2 and 6 mm.) may be expressed by the empirical formula,*

$$Y = T/D^n. \qquad (3)$$

* This formula does not necessarily apply for thicknesses below 2 mm.

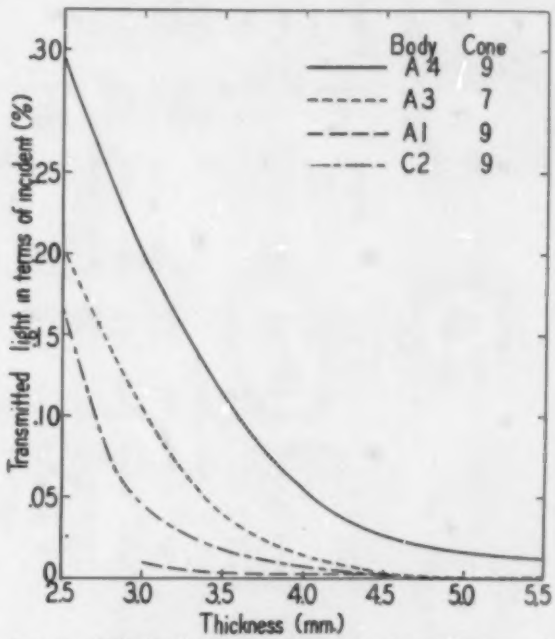

FIG. 5.—Relation between thickness and translucency of some whiteware bodies.

TABLE II

INTENSITY OF TRANSMITTED LIGHT THROUGH SPECIMENS

	At cone 5					At cone 7							At cone 9						
	Specimen thickness (mm.)					Specimen thickness (mm.)							Specimen thickness (mm.)						
Body No.	2.5	3.0	3.5	4.0	4.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
	Intensity of transmitted light for different thicknesses (microamp.)																		
A1	0.57	0.41	0.28	0.21	0.16	5.45	3.80	2.20	1.80	0.40	0.20		73.0	38.0	14.8	5.0	1.9	0.9	0.7
A2	.92	0.40	.16	.07	.10	14.00	8.20	2.20	0.90	.40	.20	0.20		50.0	16.0	8.3	7.0	2.5	2.0
A3		1.0	.45	.22	.10		3.70	1.30	0.50	.20	.20	.20		83.0	40.0	16.5	7.0	4.5	3.5
A4		1.18	.38	.29	.22		1.67	0.52	.29	.22	.20	.20	108.0	71.50	41.5	21.0	9.5	7.0	4.5
B1		0.31	.24	.20		6.90	3.50	1.50	.50	.30	.20	.20	60.4	30.0	10.2	5.0	2.0	2.0	2.0
B2		.56	.33	.20		5.8	2.60	0.90	.30	.20	.20	.20		55.0	14.2	6.0	3.0	2.0	1.5
B3		.56	.28	.42	.20	3.2	1.70	.70	.30	.20	.20	.20	100.0	48.5	21.0	11.0	6.3	4.0	
B4		.87	.39	.24	.20	1.24	0.57	.28	.20	.20	.20	.20	81.0	42.0	19.0	9.0	5.0	2.5	1.5
C1	.40	.28	.22	.18	.15	4.00	1.30	.50	.20	.20	.20	.20	24.0	8.0	3.0	1.0	0.8	0.6	0.4
C2	.70	.46	.32	.22	.15	4.00	1.40	.50	.20	.20	.20	.15	60.0	15.0	6.5	3.0	1.5	1.0	1.0
C3	1.24	.50	.28	.19	.14	2.10	0.58	.32	.23	.20	.20	.20	45.0	19.0	7.0	3.5	2.0	1.0	1.2
C4	1.04	.44	.20	.10	.10	1.30	.60	.30	.20	.10	.10	.0	57.0	21.0	9.0	4.5	2.5	1.0	1.6
D1	0.25	.23	.22	.20	.17	0.99	.38	.22	.18	.17	.17	.15	4.2	1.4	0.6	0.2	0.2	0.2	0.0
D2	.43	.25	.18	.18	.15		.36	.20	.18	.17	.15	.10	8.5	3.0	1.4	1.0	0.8	0.7	0.0
D3	.35	.21	.20	.18	.15	.78	.32	.20	.15	.10	.10	.10	18.0	6.0	2.5	1.5	1.0	1.0	1.0
D4	.52	.30	.23	.20	.15	.53	.28	.20	.15	.10	.10	.10	17.5	7.0	3.0	1.0	0.8	0.8	0.0

TABLE III

TRANSLUCENCY OF SPECIMENS (%)

Body No.	At cone 5					At cone 7					At cone 9				
	Specimen thickness (mm.)					Specimen thickness (mm.)					Specimen thickness (mm.)				
	2.5	3.0	3.5	4.0	4.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5	2.5	3.0	3.5	4.0	4.5	5.0	5.5
									Translucency (%)										
A1	0.0017	0.0013	0.0007	0.0006	0.0005	0.0150	0.0105	0.0061	0.0050	0.0011	0.0006	0.0003	0.2020	0.1043	0.0408	0.0138	0.0054	0.0025	0.0019
A2	.0025	.0011	.0005	.0002	.0003	.0385	.0226	"	.0023	"	"	"		.1390	.0523	.0235	.0193	.0069	.0060
A3		.0028	.0012	.0006	.0003		.0102	.0036	.0014	.0006	.0004	"		.2285	.1102	.0454	.0193	.0120	.0096
A4		.0032	.0011	.0008	.0006		.0046	.0014	.0008	"	.0006	"	.2970	.1970	.1142	.0564	.0262	.0193	.0120
B1		.0009	.0007	.0006		.0190	.0096	.0041	.0014	.0008	"	"	.1660	.0825	.0281	.0138	.0055	.0055	.0055
B2		.0015	.0009	"		.0160	.0072	.0025	.0008	.0006	"	"		.1510	.0390	.0165	.0083	.0055	.0041
B3		.0015	.0007	.0013	.0006	.0088	.0047	.0019	"	"	"	"	.2750	.1384	.0578	.0302	.0173	.0110	
B4		.0024	.0011	.0007	"	.0034	.0016	.0008	.0006	"	"	"	.2230	.1155	.0523	.0248	.0138	.0069	.0041
C1	.0011	.0007	.0006	.0004	.0004	.0110	.0036	.0014	"	"	"	"	.0660	.0220	.0083	.0028	.0022	.0017	.0011
C2	.0019	.0013	.0009	"	"	"	.0039	"	"	"	"	"	.1650	.0413	.0179	.0083	.0041	.0028	.0028
C3	.0034	.0014	.0007	.0005	"	.0058	.0016	.0008	.0007	"	"	.0004	.1240	.0524	.0190	.0096	.0060	.0028	.0028
C4	.0029	.0013	.0006	.0003	.0003	.0036	"	"	.0006	.0003	.0003	"	.1570	.0579	.0248	.0124	.0069	.0028	.0028
D1	.0007	.0007	"	.0006	.0005	.0027	.0011	.0006	"	"	.0005	.0005	.0115	.0039	.0017	.0006	.0006	.0006	.0006
D2	.0013	.0007	"	"	"	"	.0010	"	"	"	"	.0003	.0234	.0083	.0041	.0028	.0022	.0019	.0017
D3	.0010	.0006	"	"	"	.0022	.0008	"	.0005	.0003	.0003	"	.0496	.0165	.0060	.0041	.0028	.0028	.0028
D4	.0014	.0009	.0007			.0014	.0007	"	.0007	"	"	"	.0481	.0192	.0090	.0028	.0022	.0022	.0014

Y = transmitted light in terms of incident light (%).

T and D = constants.

x = thickness (mm.).

Although this formula was derived empirically from the data obtained in this work, it is somewhat similar to that of Lambert or Bougert ($Y = D^{-x}$). The formula presented here, however, applies more accurately to ware between 2 and 6 mm. in thickness, which are the limits of thickness of most dinnerware.

When x equals 1, Y becomes T/D, which is the translucency of a specimen 1 mm. thick. D is a constant, depending on the changes in translucency produced by variations in the thickness of the specimens. When D is large, the translucency is changed to a marked degree with variations in thickness, whereas this change is comparatively small when the values of D are small.

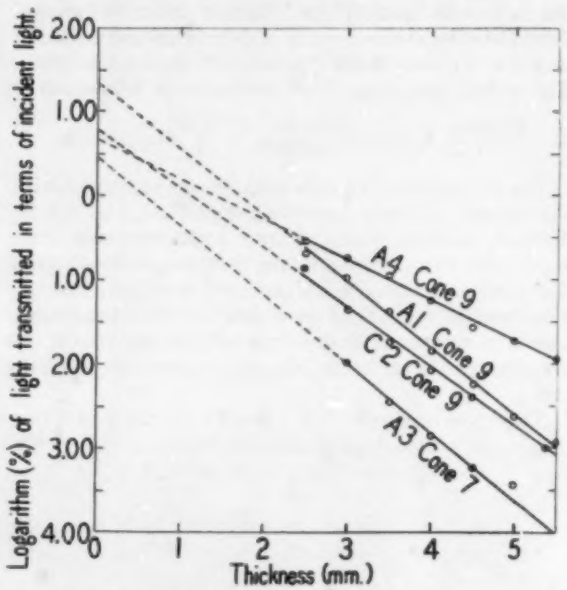

FIG. 6.—Relation between logarithm of translucency and thickness of whiteware bodies.

The values of the constants, T and D, were calculated for the sixteen bodies investigated and are given in Table IV. Figure 6 illustrates the method used to determine these values. The straight line was obtained by plotting the logarithm of the percentage of light transmitted against the thickness. The intercept on the Y axis is the logarithm of the constant, T, whereas the slope of the line is the logarithm of the constant, D.

It is apparent from Table III that body A1, which contains only lepidolite as a flux, had a comparatively short translucency range inasmuch as it had low translucency when it was fired at cone 7 but high translucency when it was fired at cone 9. This was also true of body A4, which contains only feldspar as the alkali fluxing constituent. Bodies A3 and A2, however, which contain mixtures of lepidolite and feldspar, had much wider translucency ranges inasmuch as they

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Persons Gain—Persons Lose—Persons Pay

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Date of Record	Members Paid		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
December 22, 1937	1713	220	12	523	220	2688
December 19, 1938	1815	222	26	589	220	2872
December 19, 1939	1876	237	27	642	220	3002
December 20, 1940	1995	260	25	574	220	3074
December 21, 1941	2029	257	37	609	220	3152
January 21, 1942	2043	254	38	600	220	3155

Laboratory Slag Tests Which Duplicate Practical Plant Conditions

A SLAG Test Furnace developed by Ralph K. Hursh and Chester E. Grigsby is described as "A Laboratory Furnace for Testing the Resistance of Firebrick to Slag Erosion." This furnace if carefully employed is a very useful tool in the hands of the Ceramist whose responsibility is the development of refractory products.

Figure 1 shows this slag test furnace in actual operation and figure 2 shows diagrammatically the placement of the refractories therein, including those under test. The furnace itself is essentially a vertical rotating cylinder. Next to the outer metal shell is a layer of suitable insulating brick. Next is a layer of firebrick and finally the combustion chamber itself is lined with the bricks or shapes to be tested.

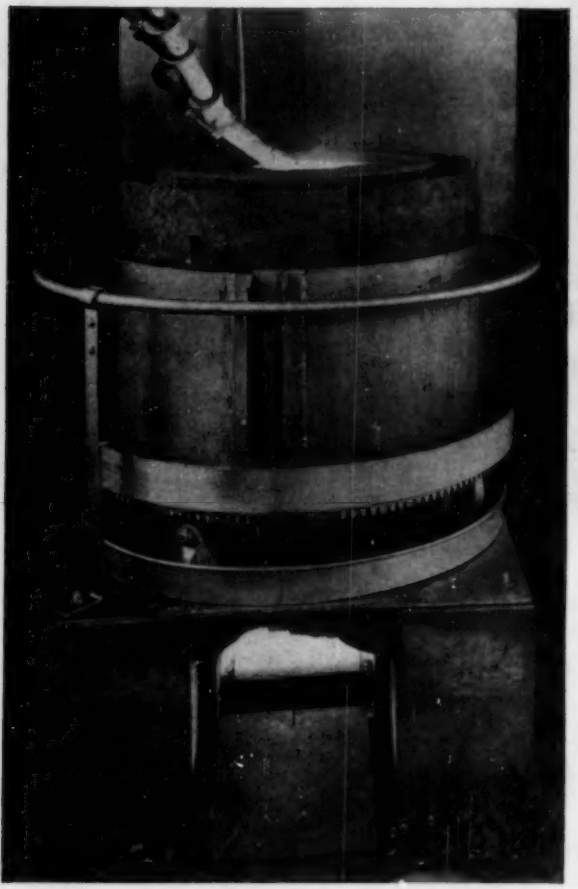

FIG. 1—SLAG TEST FURNACE IN ACTUAL OPERATION

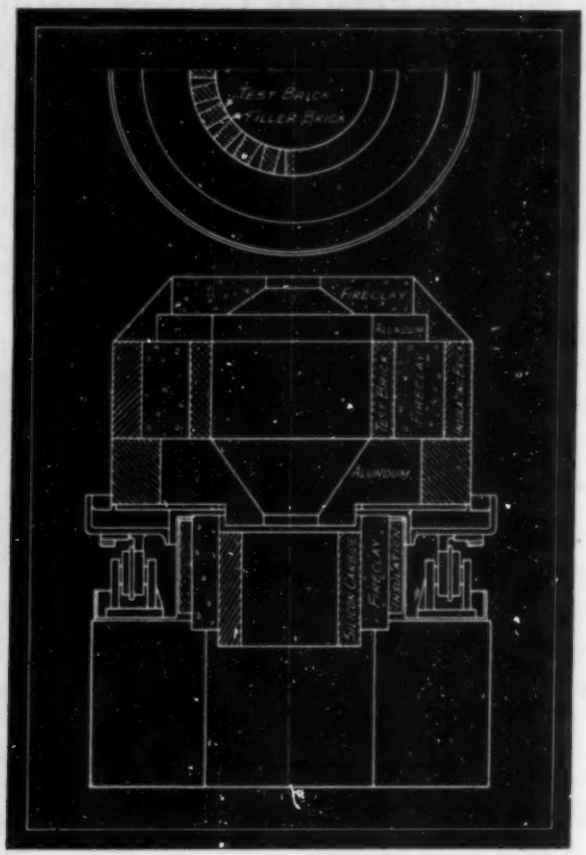

FIG. 2—DIAGRAMMATIC SKETCH OF SLAG FURNACE

Some of the desirable features of this furnace are:

1. The ease and rapidity of making tests which simulate practical furnace conditions.
2. A larger number of bricks or pieces can be tested at the same time.
3. All samples under test receive identical treatment.

Notes on how this furnace is operated can best be presented by describing the procedure followed during a recent development problem in connection with silicon carbide refractories.

On this particular problem the furnace was set up as shown in figure 1 and heating was accomplished by the use of manufactured gas. A single burner was employed and the flame directed through a hole in the top of the furnace. Ground slag sized 46 mesh and finer was fed

into the gas stream and impinged with the flame directly upon the bricks being tested, at an angle of about 30° from the perpendicular. After the slag had melted and reacted with the test brick the resulting material flowed off through an opening in the bottom of the furnace.

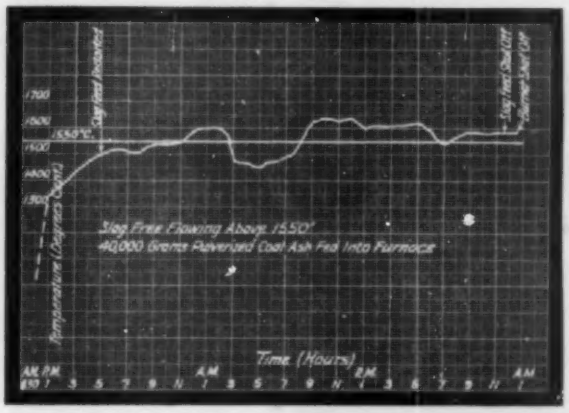

FIG. 3—GRAPH SHOWING HEATING CURVE OF SLAG FURNACE

Test specimens size 9 x 2 x 1½" were made, having an internal structure comparable to standard bricks 9 x 4½ x 2½. These were set in place in the inner lining with an exposed face of 9" x 1½". Wedge shaped separators composed of silicon carbide grains bonded with organic material were used to fill the gaps or spaces between the test specimens. Thus the test specimens and the separators formed the lining of the combustion chamber. These were backed up with firebrick and insulating brick.

Reference to the heating curve shown in figure 3 will indicate irregular heating and illustrates the difficulty in maintaining a uniformly high temperature unless a special burner is used. However, since a large number of test specimens can be treated at one time and since all are treated alike, irregular heating does not cause any great difficulty.

The test specimens consisted of a variety of mixtures but care was exercised to keep the density of all of the shapes as near as possible to the same value.

The type and amount of slag being directed into the furnace can be varied and consequently it has been possible to compare articles of the same or different composition. It has been possible to study the effect of slag upon refractory shapes containing different quantities and types of bonds and note the ratio of slag action among them. Furthermore it provides the basis for making comparison among bricks of different manufacture and also to compare bricks of the same manufacture made at different times in order to insure the continuance of a uniform product.

In the tests run in this instance, six different mixes of silicon carbide with various amounts of bond from 2% to 8% were tested, and the exact amount of slag loss for each mix carefully measured.

TABLE I

Some Illustrative Data from Slag Tests

Composition Per Cent by Weight		Burned Cone 16		
Silicon Carbide	Bond	Apparent Gravity Grams/Cu. Cm.	Calculated Porosity Percentage	Slag Test Percentage Loss
98.0%	2.0%	2.58	15.9%	11.1%
97.0	3.0	2.59	15.8	12.0
96.0	4.0	2.58	15.9	13.5
95.0	5.0	2.58	15.8	13.9
94.0	6.0	2.60	15.0	13.8
92.0	8.0	2.59	14.8	15.6

These results are graphed in a scatter diagram, Figure 4, which shows how nearly the results correspond to a theoretical formula—that for each additional 1% of bond, the per cent of slag loss increases by ¾ of 1%. While results will not correspond precisely to this formula, it appears to be a fairly good rule of thumb from tests made to date.

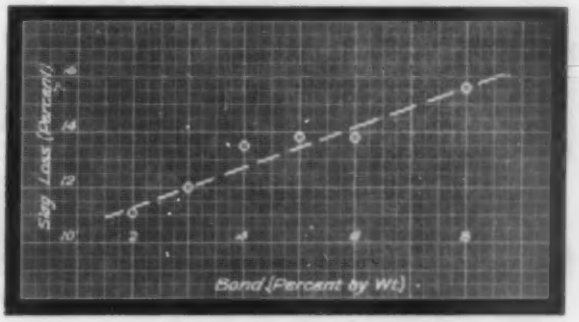

FIG. 4—SCATTER DIAGRAM SHOWING RESULTS OF SLAG TESTS

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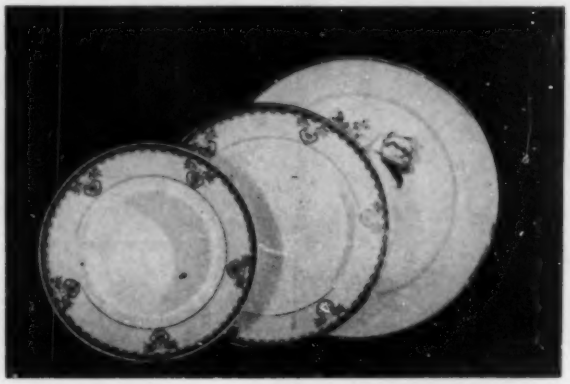

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were almost uniformly translucent after they were fired from cones 7 to 9.

A more uniform translucency, therefore, may be obtained over a wider range of temperatures by using a mixture of feldspar and lepidolite in place of either of them alone, although feldspar bodies fired to the higher temperatures have superior translucency.

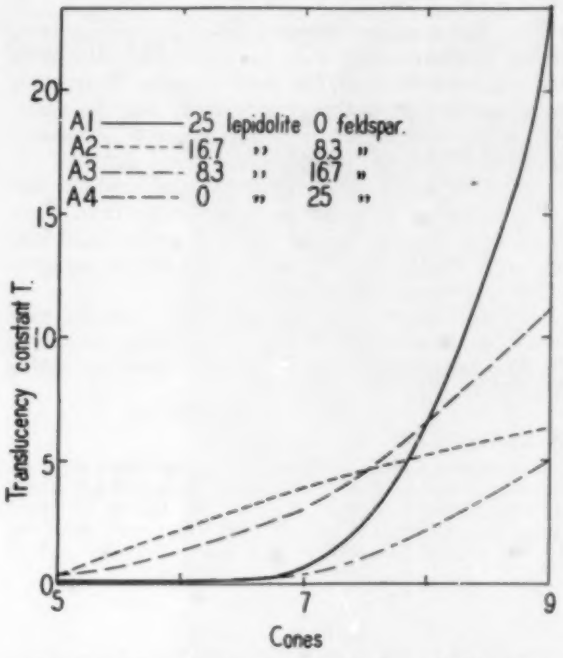

FIG. 7.—Effect of mixtures of lepidolite and feldspar on translucency constant, T, of whiteware bodies fired to different temperatures.

TABLE IV

VALUES OF T AND D FOR BODIES

$Y = T/D^x$

Body No.	Value of T (cone No.)			Value of D (cone No.)		
	5	7	9	5	7	9
A1	0.0059	0.708	23.44	1.73	4.09	6.31
A2	.142	4.000	7.08	5.19	6.05	3.90
A3	.400	3.160	11.22	5.07	6.84	3.80
A4	.282	0.400	5.02	4.37	4.65	2.98
B1	.0050	.708	15.95	1.55	4.39	5.81
B2	.020	.447	7.94	2.42	4.37	4.17
B3	.056	.398	6.31	2.78	4.52	3.62
B4	.064	0.120	5.62	2.90	4.25	3.79
C1	.006	1.319	3.39	2.02	7.20	4.90
C2	.014	1.445	6.31	2.25	7.06	4.94
C3	.173	0.850	5.62	4.92	7.41	4.68
C4	.159	.178	8.32	4.95	4.76	5.01
D1	.014	.142	1.78	2.53	4.84	7.36
D2	.045	.056	1.59	4.00	3.65	4.90
D3	.014	.141	2.00	2.87	5.62	4.71
D4	.009	.018	3.161	2.114	2.57	5.46

The relation between the absorptions and the translucencies of several bodies is plotted in Fig. 8. For equivalent absorptions, the feldspar bodies are the most translucent. The bodies which contain a mixture of 8.3 to 16.7% of lepidolite and also those with 8.3 to 16.7% of feldspar ranked next in translucency whereas the lepidolite body was less translucent.

(2) Spectrophotometer

The translucency measurements made on the thick sections in one case showed a maximum transmittance of light with a wave length of about 650 mμ (see Fig. 9). The transmittance of another specimen to light continued to rise up to 850 mμ.

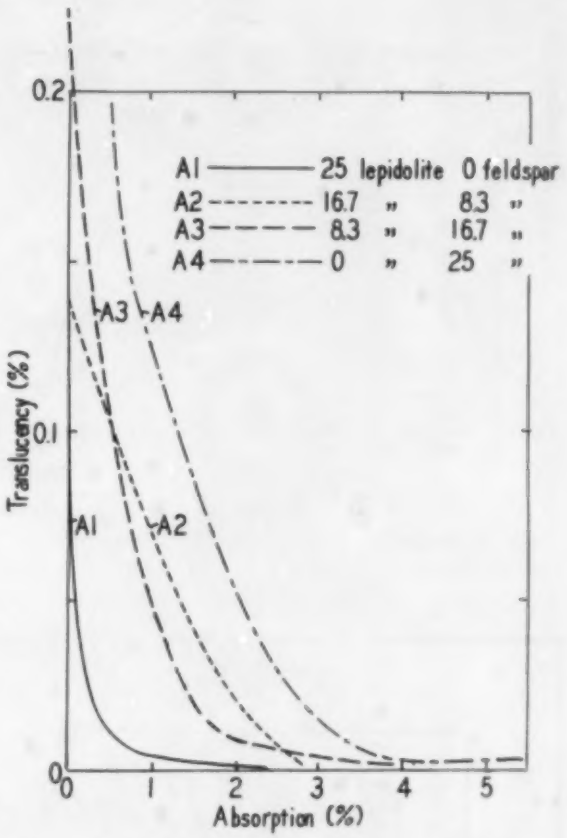

FIG. 8.—Relation between absorptions and translucency of some bodies 3 mm. thick.

The area under these curves may be used to measure the total transmittance of light through the specimens, and the areas under portions of these curves may be used to measure the transmitted ultraviolet, visible, and infrared light.

Measurements which were made on thin sections (see Fig. 9) showed maximum translucency in the visible red and infrared regions of the spectrum, and minimum translucency was obtained in the blue end of the visible spectrum.

This method of studying translucency apparently gives a more complete record of this property than is possible with the photronic cell.

This method might be used to study the amount and nature of glass in ceramic bodies as well as to reproduce more closely other types of translucent ware. A

study of the transmission of infrared light through the specimens, moreover, might be used in connection with heat-transmittance studies.

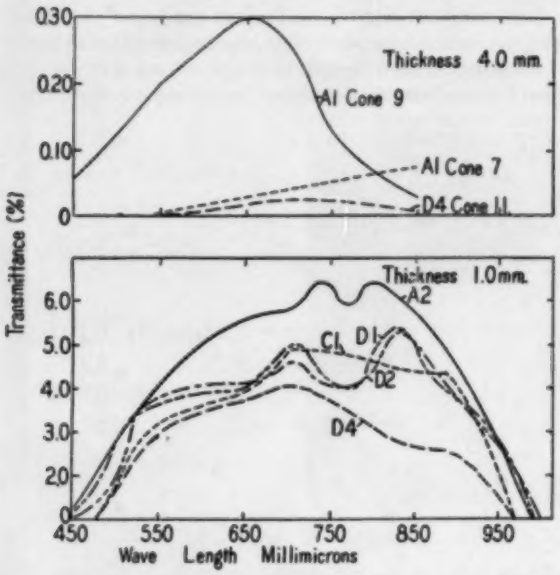

FIG. 9.—Transmittance of light of different wave lengths through translucent china bodies.

IV. Summary

(1) A method has been developed for measuring the translucency of whiteware by means of the photronic cell.

(2) An empirical formula between translucency and thickness has been derived which, for specimens between 2 and 6 mm. thick, is as follows:

$$Y = T/D^x.$$

Y = translucency.
T = constant.
D = constant.
x = thickness of specimen (mm.).

(3) The spectrophotometer gives a more complete record of translucency than the photronic cell. With the spectrophotometer, the wave length of light which most readily passes through the body may be determined. It may be used also to measure the transmittance of ultraviolet, visible, and infrared light.

(4) Bodies which contain mixtures of lepidolite and feldspar had a wider translucency range than those containing feldspar or lepidolite alone as the alkali flux, although feldspar bodies fired to the higher temperatures have superior translucency.

(5) In comparing the translucency of bodies with equivalent absorption values, those bodies containing feldspar were more translucent than those containing lepidolite.

Acknowledgment

The author wishes to express his appreciation to H. G. Schurecht and J. F. McMahon for their helpful advice and suggestions. He is also grateful to the Coleman Electric Co., Inc., for help in conducting tests with the spectrophotometer and to M. E. Holmes for helpful advice.

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THE BULLETIN

OF

THE AMERICAN CERAMIC SOCIETY

Volume 21 | February 15, 1942 | Number 2

CHARLES R. HOOK

Builder of Defense

By Timothy J. Sullivan

An increasingly heavy burden is being placed on the steel industry as the Victory program gathers momentum. Without steel an army cannot take form. Among the steel companies actively engaged in arming America is the American Rolling Mill Company, one of

the leading manufacturers of sheet steel and other steel products. During this period, when work stoppages are a matter of great concern to the nation, Armco's record of forty-two years without one hour of work or pound of production lost through labor strife takes on new significance. This is the story of the man who is president of Armco and a vital force behind that record and the Company's many contributions to a better way of living.

Charles R. Hook grew up with the tin-plate and sheet-steel industry. He was twenty-two years old when the infant Armco beckoned to him in 1902.

During the following twenty-seven years, he went through a succession of mill and management jobs with a proficiency which culminated in his election as president in January, 1930. He grew with the Company and helped make it grow. He, therefore, has a thorough and diversified background of experience for the serious business of aiding in the defense of this nation.

Two Dollars a Week

Mr. Hook was born in Cincinnati, Ohio, on July 12, 1880. The Queen City, on the north bank of the Ohio, was a bustling community. Stern-wheel riverboats streamed to and from the Public Landing. Men with handle-bar mustaches and high stiff collars "scorched" their bicycles along the roads.

After graduation from Walnut Hills High School, Mr. Hook secured a job as an office boy and received the imposing pay of two dollars a week.

His employer, the Cincinnati Rolling Mill and Tin Plate Company, was taken over by the American Tin Plate Company in January, 1899, and Mr. Hook was transferred eventually to the New York City office.

One day in April, 1900, Mr. Hook decided that he needed more practical mill training to be a good office worker, so he transferred to the Morewood Works of the Company at Gas City, Indiana, where he worked as a laborer.

About that time, the American Rolling Mill Company was being launched at Middletown, Ohio. In contrast to the long-established and adequately financed tin-plate mill in which he worked, Armco was a baby company in a highly competitive field. It kept more than half a jump ahead of the sheriff only by great management effort. Sometimes an officer would wait for the post office to open so that he could get a check from a customer and rush it to the bank to meet the pay roll.

An executive of Armco who had known young Hook as an eighteen-year-old office boy suggested that the management contact him. They did not have much to offer in dollars and cents, but Mr. Hook listened to their ideas and heard something more important than the clink of silver dollars on payday. He heard a new and sound outline for operating a business.

Offered a job as night superintendent at $100 a month, he packed his belongings in Indiana and cast his lot with these men and their ideals.

Still a Mill Man

To the boys who worked with him in those days he is still a "mill man." Mr. Hook started in the mill and has never lost a clear insight to the problems of operations.

As he rose through the mill, he contributed in measurable terms to the rise of Armco. The day that he sat on a bench in front of the original open-hearth furnace and accepted his first position he knew that the Company's goal included a full understanding between men and management. Mr. Hook did much to make that a reality. The Company did not use an approach of paternalism or philanthropy. It merely recognized the dollars-and-cents advantages of well-founded confidence and proceeded to establish that base under the infant organization. Many of the stones in that foundation were either set by or inspired by him.

Basically, Armco's program was to provide free access to the men of the management, to consistently strive to improve working, community, and living conditions, and to convincingly exhibit interest in establishing a wealth of wholesome recreational facilities and many other activities.

As Charles R. Hook progressed to sheet-mill superintendent, assistant general superintendent, general superintendent, operating vice-president, vice-president and assistant general manager, vice-president and general manager, and then president, he made these definitions of fair treatment consist of more than just spoken words or a written slogan. He made sure they were measurable in dollars and cents, working conditions, promotions, and general appreciation for work well done.

Mr. Hook was not only putting ideals into the practical terms of steel-mill operations, but he also was contributing ideas for improvements in steel products and in their manufacture.

As great as his contribution to employee relations was his advancement of the mill itself—he was a mill man.

John B. Tytus, working in the Armco hot mill at Middletown, played with the idea of making steel in long wide sheets by continuous rolling (in much the same way that paper is made). It seemed virtually impossible to accomplish this, but Mr. Hook encouraged him. In the spring of 1924, the world's first successful continuous-sheet rolling mill went into production in the Armco plant at Ashland, Kentucky. Here was a sample of what could be done when vision, ability, courage, resourcefulness, and cooperation were coordinated under the American private enterprise system.

Partial List of Activities

Mr. Hook has been a member of the executive committee of the National Association of Manufacturers since 1933. He was elected president of the N.A.M. in 1938. In 1939, he was chairman of the board of that organization. He has been a member of the National Industrial Conference Board for a number of years. He was also chairman of the Industrial Relations Committee of the International Management Conference which was held in the United States in 1938. He was vice-chairman of the Committee for Economic Recovery which made a long and careful study of housing and housing needs in the United States and abroad. In 1938, he was appointed by President Roosevelt as a member of the Commission to go abroad to study labor conditions in England and Sweden. In May, 1941, he was elected president of

Junior Achievement, the national youth program established to prepare boys and girls between sixteen and twenty-one for business through the operation of their own small manufacturing companies. He is an active member of the Business Advisory Council of the Department of Commerce and serves as chairman of the Industrial Relations Committee of the Council.

Mr. Hook has also devoted much of his time to community activities in his home town of Middletown, Ohio.

Although Mr. Hook never attended college, three universities have conferred degrees upon him. In 1935, he received the degree of Doctor of Engineering from the Michigan School of Mining and Technology. In 1939, he received the degree of Doctor of Laws from Ohio State University and the degree of Doctor of Commercial Science from Oglethorpe University. He is also a member of the Corporation of the Massachusetts Institute of Technology.

Under the pressure of current capacity operations, recreation is important. Mr. Hook enjoys playing golf and is often a spectator at baseball and football games and at other outdoor contests. He gets more real enjoyment, however, out of employee activities.

Armco and Defense

When the defense program got under way, the Armco management, under Mr. Hook's guidance, kept in almost constant contact with National Defense officials in Washington. They were anxious to determine how Armco could effectively plan and do its full share, improving present facilities and constructing new ones.

When these defense constructions and improvements are finished, the cost will be close to $60,000,000.

Part of these facilities will be owned by the government and operated under lease by Armco.

ACTIVITIES OF THE SOCIETY

EXECUTIVE COMMITTEE MEETING OF THE AMERICAN CERAMIC SOCIETY

Held December 4, 1941, in the Corning Glass Works Club Room at the Hotel Baron Steuben, Corning, N. Y.

The following persons were present at 9:30 A.M.: J. T. Littleton, V. V. Kelsey, F. C. Flint, George J. Easter, J. F. Greene, H. R. Lillie, J. E. Frazier, Major E. Holmes, S. R. Scholes, Robert E. Campbell, E. S. Stebbins, Ross C. Purdy, Arthur A. Wells, Ralston Russell, Jr., R. C. Benner, J. D. Sullivan, H. G. Wolfram, J. W. Whittemore, W. C. Taylor, J. F. McMahon, C. H. Commons, Jr., C. Forrest Tefft, R. R. Shively, and Donald E. Sharp.

The meeting was called to order by President Littleton.

DR. PURDY: The following financial statement for November, 1941, will be the basis for discussions and decisions here.

Balance in banks, October 31	$ 6,330.23	
Receipts for November	2,257.48	
	8,587.71	
Disbursements for November	6,951.60	
BALANCE IN BANKS		$ 1,636.11
U. S. Saving Bonds	11,710.00	
Treasury Bonds	409.16	
Savings Certificate	3,000.00	
Defense Bonds	6,000.00	21,119.16
ACCOUNTS RECEIVABLE		
1940 Accounts Receivable	178.23	
Old publications	163.70	
Subscriptions	1,262.24	
Reprints	281.79	
Advertising	1,329.35	3,215.31
UNPAID BILLS		
November *Bulletin* bill	$ 1,023.36	$ 1,023.36

BALANCE SHEET & COMPARISON (Nov., 1940, with Nov., 1941)

ASSETS	1940	1941
Cash in Ohio National Bank	$ 2,357.09	$ 835.47
Cash in Huntington Bank	3,094.85	200.64
Cash in Northern Savings Bank	600.00	600.00
Revolving fund	300.00	300.00
Petty cash	5.00	5.00
	6,356.94	1,941.11
Invested reserve	11,861.16	21,119.16
Accounts Receivable	3,088.44	3,215.31
	14,949.60	24,334.47
Annual Meeting	70.54	53.10
TOTAL ASSETS	21,377.08	26,328.68
LIABILITIES		
Accounts Payable	1,109.38	1,023.36
Fellowship Fund	1,687.28	1,416.89
Building Fund	10.00	10.00
Orton Medallion	16.00	16.00
Institute of Ceramic Engineers	634.78	825.74
Enamel Bibliography	2,525.30	3,380.30
Prepaid Personal dues	651.75	482.00
Prepaid Corporation dues	75.00	100.00
Prepaid subscriptions	349.83	386.40
	7,059.32	7,640.69
INCOME NOT EARNED		
Dues: Personal	1,810.65	1,869.78
Dues: Corporation	533.14	535.41
Subscriptions	475.82	474.55
	2,819.61	2,879.74
TOTAL LIABILITIES AND INCOME NOT EARNED	9,878.93	10,520.43

DR. PURDY: A reserve of $21,000 is not excessive.

Regarding the question of "Why not decrease the dues?" a special committee, appointed to consider lowering the dues for certain classes of members, reported against any change in dues charges. We are certain to suffer losses owing to enlistments here and abroad. The report of that committee appears on page 368 of the October, 1941, issue of *The Bulletin*.

The following table shows what loss we will have owing to the discontinuance of postal service with certain foreign countries.

COUNTRIES FROM WHICH WE ARE WITHHOLDING PUBLICATIONS

	Subscriptions				Memberships				
	No.	Amount paid or ordered in 1941	Amount owing in 1941	Amount due for 1942	Personal	Corporation	Amount paid in 1941	Deferred	Amount owing on deferred
Siam	1	$ 12.50		$ 12.50					
Manchuria	3	37.50		37.50					
Holland	5		$ 62.50	62.50	1		$ 50.00	3	$ 37.50
Germany	22	118.40	30.30	148.70	16	1	225.00	5	100.00
France	6	40.50	25.00	65.50	1		12.50	3	37.50
Italy	7	56.00	25.00	81.00	2		25.00		
Japan	117	303.50	1,054.50	1,358.00	11	4	212.50		
China	12	165.40		165.40	6		75.00		
Belgium	1	12.50		12.50					
Czechoslovakia	1	Exch.							
Hungary	1	12.50		12.50	1		12.50		
Denmark	1	15.50		15.50	4		37.50		
Norway	1	15.50		15.50	3		30.00		
TOTAL	178	$789.80	$1,197.30	$1,987.10	45	5	$680.00	11	$175.00

Probable income loss (1942), $4,039.40

DR. PURDY: We would like to print more papers, but a budget limitation of $20,000 has been the aim. We are fearful, however, that we will exceed this budget by $400 or $500 when the Indexes are printed.

DR. MOREY: Do you have any idea of the possible increase in cost for next year?

DR. PURDY: The cost of paper and of labor are up. Our printing contract for 1942 is the same, however, as for 1941.

DR. LITTLETON: It might be well to have a reserve fund of approximately $50,000 or possibly we could better spend the money in increased activities. An increase in activity and an increase in earning power should follow from increased membership.

MR. SULLIVAN: How much reserve did we have before the last depression and how badly was it affected?

DR. PURDY: The following chart shows the record:

Year	Printing costs	Invested reserve	Salaries
1927	$16,134.37	$ 9,861.00	$13,786.65
1928	18,181.80	9,861.00	13,908.62
1929	20,374.76	10,280.02	13,769.30
1930	22,676.95	10,719.84	14,759.75
1931	19,658.53	11,175.79	13,905.00
1932	13,570.80	10,279.44	12,313.25
1933	13,175.69	8,162.79	11,420.01
1934	12,475.81	4,610.40	12,598.13
1935	16,181.35	3,176.31	13,120.76
1936	15,646.82	2,501.76	15,372.29
1937	16,181.35	7,864.26	16,837.50
1938	19,897.79	7,958.16	17,191.50
1939	20,455.29	11,861.16	17,553.25
1940	20,941.20	12,119.16	17,940.00
Nov. 1940	20,662.03	21,119.16	18,547.25

MR. WELLS: In considering a reserve that would be adequate for an extended depression, the following basis might be used: A reduction in income of 10% of the base year for five years, i.e., 10% off the first year, 20% off the second, and so 30, 40, and 60%, or a total drop in income for five years of 150% of the base year income. Taking the base year's income as $45,000, at the end of five "sick" years we would be short $67,500.

There would, however, be a reduction in expense of approximately one-half the loss of revenue and that would be available the year following the saving, e.g., the first year, nothing; the second year, one-half of the first year's loss of revenue or 5%; the third year, 10%; then 15 and 20%; or, for the five years, a drop in expenses equal to 50% of the base year or $22,500. Subtracting this from the $67,500 would leave a sum of $45,000, which should be sufficient to carry us through five bad years.

This might be entirely wrong, but it indicates one method of approach to the important problem of how to financially bulwark an important technical society in good times against the inevitable future depression. A technical society takes an awful beating when salaries are cut, but it is just in times when that occurs that they have their greatest value to the industry and to our economy.

Currently, with money loose, salaries increasing, and income taxes getting higher, I feel that it would be wise to shoot for a higher reserve than can be presently justified and that this reserve should be kept as liquid as it has been in the past.

We know that winter is coming, so let's lay in an extra cord of wood.

DR. LITTLETON: I think it is probable that operating expenses would be cut when we begin to lose income.

DR. PURDY: We have been overworking Miss Eckardt. She is just tired out, and I have insisted that she come to the office late and have Saturdays off, but she continues on. She had to have more help. Without authorization, another girl was employed, one who is very capable and who has applied herself most thoroughly right now when the office is at its peak load. We cannot expect Miss Eckardt to work overtime and as hard as she has been doing.

DR. LITTLETON: Was not the employment of a girl approved by the Finance Committee?

DR. PURDY: Yes, some four months ago. We asked to substitute a more highly trained assistant at $100 a month for a $70 clerk which we let go. This new girl, Miss Warner, worked with Miss Van Schoick on *Journal* papers for six weeks; in the meantime, she studied the Indexes of the last two years. She has written the Subject Index of *Ceramic Abstracts* without more than occasional advice, and she has done a very accurate job.

Our staff must be prepared to go on, even if one should drop out. We have to have more than one person capable of doing any of the tasks of editing and accounting. This we now have.

DR. LITTLETON: A surprising amount of business is going through the office. Ways of paying for the assistance must be found.

DR. PURDY: The profit for 1941 will be cut by this employment of additional help.

MR. FLINT: Instead of $45,000 for running expenses, it probably will run closer to $50,000.

A budget of $50,000 represents so many members; as members increase so does the budget, but not in direct ratio. The budget should be on a sliding scale, i.e., so much per hundred members.

DR. LITTLETON: I would like to hear a recommendation regarding an adequate reserve fund put on the basis of percentage operating expenses rather than total number of members. There is no question as to what we may face if the present national activity stops. The membership of a technical group and the activities of this technical group should increase. The importance of this Society to industry and to this country is going to increase as the emergency grows. The Society becomes even more of a necessity, and this necessity should lead to a recognition of our value and to an increase in membership. This, however, will probably not happen. We will be forced to retrench. A loss of membership and of revenue will be certain. We must consider now what we can do to care for the situation which will develop. Shall we increase the reserve fund or try to increase the earning power of The Society?

DR. MOREY: I move that the discussions and considerations which have been brought out, particularly the point of view brought out by Mr. Wells, be reported to the Finance Committee for its consideration and advice regarding the reserve fund.

This motion was seconded by Mr. Sullivan.

DR. LITTLETON: A review of other societies shows that The American Ceramic Society has almost twice as high a percentage of its membership attending its Annual Meetings as that of the other societies. Also, about 57% of those who register at the Annual Meeting are members and 43% are nonmembers.

Date	Total paid members of The Society	Meeting place	Registration			Total paid members attending (%)
			Total	Members	(%)	
1934	1444	Cincinnati	620	398	64.1	27.5
1935		Buffalo				
1936	1487	Columbus				
1937	1843	New York	934	534	57.1	28.9
1938	1996	New Orleans	528	303	57.4	15.1
1939	1925	Chicago				
1940	1996	Toronto				
1941	2306	Baltimore	1147	660	57.5	28.6

The large percentage of nonmembers attending the Annual Meetings is a point to be discussed. My judgment would be that these Meetings have not been handled in such a manner as to be a recruiting ground for new members. I think we should consider what we can do toward recruiting members from the nonmembers who are sufficiently interested to attend but who do not join. We have something to offer to bring them out to the Meetings. Why, therefore, do they not join?

Should we have a higher registration fee for nonmembers or should this be the same as for members?

DR. MOREY: The registration fee should be higher for nonmembers than for members.

MR. KELSEY: Perhaps we should charge nonmembers a registration fee amounting to dues for one year or proportion the dues for the next three quarters based on yearly dues and registration fees and give them badges.

DR. MOREY: What is the amount for registration?

DR. PURDY: Unless they are sufficiently interested to pay the $12.50 annual dues and the $5 registration fee, they will be off and on our files.

DR. MOREY: Is there any objection to charging nonmembers a higher fee, with the understanding that it would be as a payment on annual dues?

MR. GREENE: Memberships should be solicited from friends and from the office of the General Secretary. The nonmembers attending the Meetings have already made a partial choice and should pay a little extra and perhaps have a follow-up.

MR. FLINT: There is a difference in not joining and not functioning, and nonmembers attending our Meetings should pay a certain amount more.

DR. PURDY: Some material and equipment firms send a group, all of whom do not register. They trade badges to avoid paying a $5 registration fee. They are attending on expense appropriations but spend it on entertainment. Such cases are few in number, but at each Meeting we have such cases.

The hotels have had more registered on account of our Meetings than we have had registered with us. This has been true at all of our Meetings.

Local people are not much trouble. There are a few papers in which some of the local employees are particularly interested and they wish admission without fee to those particular sessions. If their firms are Corporation Members, we pass a few of such men in without fee.

MR. FLINT: There should be a difference. I believe some societies charge extra for those not belonging and they have another kind of badge. You can therefore tell the members from the nonmembers. The difference would be noticeable.

MR. SULLIVAN: Not many societies do this. The A.I.M.M.E. has no registration fee. The nonmembers pay $1. On the whole, not many societies charge a difference.

DR. TAYLOR: Would you collect more if the fee were lower?

DR. PURDY: We had the same trouble when $2 was charged.

DR. LITTLETON: How could we handle the registration so that we would not refuse some professional people? The Art Division, in particular, has a number of people interested who should, but do not, belong to The Society. Is there some way of especially caring for the Art people?

DR. PURDY: In Cincinnati there may be some art students who wish to attend the meetings, and it is in their behalf that a special badge without fee has been requested.

MR. FLINT: Why be so anxious for them to come? Run the Meeting for members and those who want it badly enough to pay for it.

MR. WOLFRAM: In Baltimore we had boys in laboratories who did not have individual memberships. They could not all attend at one time; some went for one session and some for another. It is quite expensive to pay for all. Something could be worked out, for example, a blanket registration for a company.

DR. MOREY: Those boys are not members of The Society because of membership cost. If they had to pay a registration fee they would not attend the Meetings.

MR. GREENE: If they are allowed to attend the Meetings, it might lead to their joining The Society.

MR. FLINT: A Corporation Member should be permitted to send any number it wants.

DR. PURDY: You must remember that any dragnet method for securing members results in a loss, not in a gain. The present procedure is the best. We write to nonmembers who have registered and ask them to join. We solicit their membership. We get some in this way who have attended Meetings for two and three years.

DR. MOREY: I move that the Secretary charge nonmembers a 50% larger registration fee than members, provide them with a different badge, and that the Secretary, in cooperation with the Chairman of the Division, handle special applications.

DR. LITTLETON: The motion brought before us is broad enough to allow the Art Division a release if it so desires.

Mr. Flint seconded the motion.

DR. LITTLETON: This could be handled by two separate registration desks, one registering members and one registering nonmembers. The members of the Membership Committee could be there to show the aims and accomplishments of The Society. If the nonmembers want to join, they can pay $17.50 and get membership and regis-

tration; otherwise they may register for $7.50. A second motion might be required now to cover this.

DR. LILLIE: The nonregistered delegates come for lobby contact.

DR. PURDY: Our present system is working all right. Charts do not show an increase in membership following a Meeting. The increase comes later. Ray Birch showed this in a chart which was distributed to each of you.

DR. LITTLETON: These Meetings as a rule show a slight loss. They should be self-supporting.

DR. PURDY: They are self-supporting with the $5 registration fee. When a $2 and $3 fee was charged, the Meetings were run at a loss.

DR. MOREY: The two proposals should be separate: (1) a registration fee for nonmembers; (2) allowing the Secretary, in cooperation with the Chairman of the respective Division, to dispense with the fee at his discretion.

DR. LITTLETON: The motion is made and seconded that authority be delegated to the Chairman of the Division and the Local Committee to issue invitations and to act on invitations for admission to Meetings.

The motion was carried.

PROFESSOR WHITTEMORE: Shall the registration fee be kept the same for members and for nonmembers?

MR. FLINT: Why not lay that on the table until another meeting?

A motion to lay this on the table was seconded by Professor Whittemore. The motion was carried.

DR. LITTLETON: The next thing is Item 2 on the Agenda, Society Prospectus.

The form, text, and possible cost were extendedly discussed.

Mr. Sullivan moved that The Society favor the prospectus. The motion was seconded by Professor Whittemore and carried.

DR. LITTLETON: Now for a discussion on preparing such a prospectus. What standing committee would this be a function of?

DR. MOREY: Would it be unreasonable to ask the Secretary's office to prepare a Society prospectus and obtain a quotation from an advertising firm?

DR. LITTLETON: It might be referred to a committee to advise at the next Board meeting. This is passing the buck, but it may save the money. Would you care to make the motion that the Secretary's office be given authority to prepare such a prospectus even to the point of seeking advertising help?

The motion was made by Mr. Flint, seconded by Professor Whittemore, and carried.

Agenda Item 3, Student Branches and Local Sections

DR. LITTLETON: Some members think that we should be in closer touch with the Student Branches and Local Sections. I think they are right. So far, from the administrative end, The Society has given very little attention to either one. Our Secretary's office, however, gives them considerable attention. They are most important parts of The Society and are excellent recruiting grounds for members.

DR. LITTLETON: What is the New York State Ceramic Association?

DR. PURDY: It is a state organization similar to those in Ohio, New Jersey, and Illinois. They are fine and The Society should give them every support. They are wholly apart from and independent of this Society; they are, however, wholeheartedly cooperative and in no wise competitive.

This Society does have Local Sections. There are three on the west coast. In the east and middle west we have the Pittsburgh, St. Louis, Michigan-Northwestern Ohio, Baltimore-Washington, Chicago, and Central Ohio Local Sections.

MR. SULLIVAN: Membership in the Local Sections is not restricted to members of The American Ceramic Society?

DR. PURDY: That is true.

DR. MOREY: Item 8 in the Agenda wants specific duties assigned to the Vice-President. Why should he not take the task of contacting the Student Branches and Local Sections?

DR. LITTLETON: He might.

MR. FRAZIER: Obtaining a speaker is a difficult job. One who is paid usually has something interesting to say, although sometimes not. It is not always easy to find a speaker for a Student Branch meeting.

We have enough active members of The Society in each section of the country so that a talk on the activities of The Society, the reasons for The Society, its aims, etc., could be given. Such a talk would not cost anything. Data presented by Dr. Purdy would be interesting. In our Section, we have a lot more nonmembers than members. We are not using it, however, to try to bring them in.

DR. MOREY: In making the suggestion that the Vice-President be assigned the task of contacting Student Branches and Local Sections, I thought that the Student Branches would get a big kick out of an official of The Society being interested in them.

DR. PURDY: The attendance depends on the locality and the local interest. Mr. Ferguson had a group in Pittsburgh which he seemed to lead in a very happy social after each meeting. The Michigan-Northwestern Ohio Section has somewhat the same type of meeting. It gets men acquainted.

The Southern California Section always gets a crowd and not all of them are members. They always have a social time together.

DR. MOREY: In Washington they want a paper and, after it is finished, they go home.

MR. SULLIVAN: A visit by the Secretary and the President to each Student Branch or Local Section might be satisfactory. If the President could not go, the Vice-President might carry on. Many societies are doing this. The American Chemical Society and the Mining & Metallurgical Institute had a big turnout on the west coast.

MR. FLINT: We might divide the country into three parts and have the President, Vice-President, and Secretary each take a section. Split up the work and time and have a schedule worked out which would give the time when the students are meeting. In this way an annual contact could be made with the whole country without overburdening any one individual.

DR. LITTLETON: We must face the situation, not just float along.

DR. MOREY: Could you appoint a committee to formulate policies in regard to this matter, to look into actual expense, and to report back to the Board at its next meeting?

DR. LITTLETON: We have such a committee. It should be advised that we favor a scheduled program of representatives appointed by the committee to attend meetings of Student Branches and Local Sections.

MR. SULLIVAN: The Finance Committee should be referred to for consideration in bringing up its budget. The Finance Committee could possibly find ways and means of taking care of such a program.

Dr. Littleton asked for a motion in favor of further extension of The Society's activities. It was moved by Mr. Sullivan and seconded by Professor Whittemore.

Mr. Flint moved that the Finance Committee report at the next meeting. The motion was seconded by Dr. Morey and carried.

DR. LITTLETON: Mr. Easter and Mr. Benner will present their proposal of "Defense of Professional Status of Ceramists."

NOTE: This is printed on page 9 of the January, 1942, issue of *The Bulletin*.

It was discussed at length.

MR. COMMONS: What is a "ceramic technologist" and a "ceramic engineer?" Most ceramic graduates could be called technologists or engineers. There is not a sufficient distinction between them.

MR. FLINT: The following schools are accredited by E.C.P.D.: University of Illinois (technical option), Iowa State College (1940), Missouri School of Mines and Metallurgy, New York State College of Ceramics (at Alfred University), North Carolina State College, Ohio State University, Pennsylvania State College (Ceramics) (1938),

Virginia Polytechnic Institute (1938), and University of Washington.

Some engineers are good technologists with very little engineering training.

The E.C.P.D. is run by five founders societies plus state boards.

DR. HOLMES: When you face the E.C.P.D., you have no doubt as to which class you are in.

MR. EASTER: Does this group think it worth while to bring the matter up for more consideration?

DR. PURDY: Mr. Easter suggested time at the Annual Meeting.

MR. EASTER: Possibly the appointment of a committee would be better.

MR. FLINT: It seems all right. Should we organize an Institute of Ceramic Technologists?

MR. COMMONS: Could it not be the function of The Society to protect the interests of its members and form necessary committees to protect artists, technologists, and engineers? Are separate organizations necessary?

DR. LITTLETON: If this were to be presented at a Meeting, a committee should be formed and given opportunity to render its case.

MR. BENNER: I make a motion that the President appoint a Committee on Professional Status to look into what The Society should do to protect its members.

The motion was seconded by Mr. Commons.

DR. LITTLETON: We should have about five persons on that Committee. It needs good representation. I am appointing Mr. Easter as Chairman, and Mr. Flint, Mr. Commons, Professor Greaves-Walker, and C. E. Bales.

MR. BENNER: Is it your suggestion that this Committee take care of the Meeting?

DR. LITTLETON: Yes.

Agenda Item 5, Pension Plan for Employees

DR. PURDY: We have no pensions. We are not participating in Social Security. We do not have to comply, inasmuch as we are a nonprofit educational organization.

DR. MOREY: Can you join now?

MR. SULLIVAN: The decision has already been made that we are not to join. I doubt if we can get in now.

MR. GREENE: There is some consideration going on in Washington now concerning nonprofitable organizations.

MR. SULLIVAN: We should have some form of pension. Most organizations seem to have. The common system is to deduct 3% of the salary, which is matched by a like amount by the organization.

Our pay-roll salary amounts to $20,000 a year. We would provide $600 per year as our portion of the retirement fund and the employees would match this.

MR. COMMONS: Can we afford it now and keep on doing so three or four years from now when things go down?

We should pay a higher scale of wages when we can. Let the employee take out his own savings.

MR. SULLIVAN: If this were true, there would be no need for Social Security.

PROFESSOR WHITTEMORE: I agree with Mr. Sullivan. Some pension plan is necessary and it would not be a hard burden on The Society. We owe it to those who have worked so faithfully.

MR. BENNER: Would you make it retroactive?

MR. SULLIVAN: That depends on the plan. If it were with an insurance company, we would have to buy annuities. Could we get an annuity on Dr. Purdy? There are very definite limits. The age limit, I believe, is fifty-six.

PROFESSOR WHITTEMORE: Was a committee ever appointed to look into this?

DR. LITTLETON: It was discussed, but no definite action was taken. We should have a definite committee appointed to investigate the different methods of handling this situation.

Further discussion was postponed until Mr. Moorhead of the Corning Glass Works could be brought in.

Agenda Item 6, Payment of Traveling Expenses to Board Meetings

DR. LITTLETON: This matter was discussed somewhat at Baltimore and definitely turned down. I, for one, was opposed to it at that time. Since that time, however, I have a great deal to say for it. There are two men on our Board who would be an asset right here now and it would be worth much to have them present. A reasonable amount should be allowed; for instance, there should be no allowance for a trip from California. An allowance should be set at a certain amount.

MR. SULLIVAN: This was discussed at the Board meeting at Pittsburgh also, primarily in the interest of educational men.

MR. COMMONS: How often does this Board meet? Could the total expenses be kept within $200?

MR. SULLIVAN: The question brought up at the Pittsburgh meeting dealt with expenses allowed at Board meetings and not at Annual Meetings. Not more than $50 should be allowed for any individual.

DR. LITTLETON: Of course there is something to be said about members not accepting an appointment to the Board if they are not able to attend the meetings.

MR. COMMONS: Should it be only educational men?

DR. LITTLETON: I would hardly think so.

MR. SULLIVAN: Perhaps the Board members attending should be allowed to turn in expense accounts.

DR. LITTLETON: Does anyone care to make a motion? It is not necessary to make a motion unless there is a change in policy. The policy now is not to pay.

No motion was made.

Agenda Item 7, Authority of Dean of Fellows to Appoint Committees

DR. LITTLETON: At the last meeting of the Board, the Fellows requested that the Dean of Fellows be given authority to recommend certain committee appointments. There is an advantage in that as he has a three-year term of office. He is in a better position than an incoming President who might never have been on the Board.

I feel that it was an improvement over what has been done. The matter of each individual committee should be brought up and the appointments recommended at a meeting of the Board.

MR. FLINT: Did the Fellows ask for authority to appoint the committees?

DR. LITTLETON: They did.

MR. COMMONS: Read the first paragraph of Article IV. This should preclude this.

DR. LITTLETON: We gave them permission to advise us.

MR. COMMONS: In that case, if they do not make an appointment within a week or so, we could go ahead and make them.

DR. LITTLETON: We did not agree that we would follow recommendations.

PROFESSOR WHITTEMORE: The whole idea was, I believe, that Dr. Sosman would have his committees ready for the next meeting.

MR. FRAZIER: Was it done to speed up appointments or was it just an honorary idea? If the idea is to speed up these committees, the two Past-Presidents could advise better than any other.

MR. COMMONS: If the Dean were to function quickly, it could be a valuable recommendation. If that is not so, a time limit should be set.

PROFESSOR WHITTEMORE: I move that the Dean of Fellows be required to submit his recommendations to the President at least two weeks before the Annual Meetings.

The motion was seconded by Mr. Wolfram and carried.

Agenda Item 14, Special Badges for Art Division Guests

MR. FLINT: A motion has already been made allowing the Section head and Secretary of the Local Committee to take care of this very thing.

MR. COMMONS: I move that a pass be provided for those nonmembers and for those approved by the Chairman of the Division and Secretary of The Society.

The motion was seconded by Mr. Frazier and passed.

Agenda Item 10, Employment Service at Annual Meetings

MR. FLINT: The American Chemical Society has a very

complete service. A blank is filled out and classified and a room is provided for interviews. A man may have several classifications.

PROFESSOR SCHOLES: There should be a bulletin board for those interested.

MR. FLINT: What value is that service to us?

PROFESSOR WHITTEMORE: A lot of value. Before this service was set up, the students did not meet the industrial men.

MR. GREENE: Did they make any contacts?

PROFESSOR WHITTEMORE: Four of them did.

MR. COMMONS: The idea is a good one, but it needs improvement.

PROFESSOR WHITTEMORE: Many of the industrial men knew nothing about it.

DR. PURDY: The boys wanted to set it up. It was set up on the second day and was under motion on the third day. It should be announced to the boys and to the members. This is a job for the Ceramic Educational Council.

MR. FLINT: The concensus of the Board was that it should be referred to the Ceramic Educational Council.

A motion was made to bring this to the attention of the Ceramic Educational Council at once so that it could get under way.

The motion was seconded by Mr. Frazier and passed.

Agenda Item 11, Employment Service in *The Bulletin*

This was not discussed.

Agenda Item 5, Inauguration of Pension Plan for Society Employees

DR. LITTLETON: It was agreed yesterday to postpone Item 5 until we could get more definite information on it. H. R. Moorhead, Jr., assistant treasurer of the Corning Glass Works, has been making a study of this type of insurance and security and has consented to describe some of these plans and perhaps help in what plan might be best suited for us. We may need more material and data, however, for this pension or annuity which was brought up.

MR. MOORHEAD: It is a question of pensions or life insurance. Annuity and pension are the same thing. Employees retire at the age of sixty-five. Any plan depends on the number of employees.

MR. SHARP: Is it also a matter of length of service as well as the rate of pay?

DR. PURDY: Three persons in our office have been employed for twenty years; two persons have been employed for about fifteen years.

MR. MOORHEAD: How many employees around thirty or thirty-five years of age do you have?

DR. PURDY: Six are thirty-three or younger.

MR. MOORHEAD: For a small group you need a substantial reserve.

MR. FRAZIER: What happens if they leave after a short time?

MR. MOORHEAD: Some pension plans call for giving back their money at a rate of interest. Turning the money over to the employee is optional.

MR. MOORHEAD: Three plans are available: (1) handle it yourselves, (2) through an insurance company, (3) through a bank.

DR. LITTLETON: Let us have a motion on what our policy should be.

A motion was made by Dr. Morey that The Society consider this on a pension plan only. It was seconded by Mr. Sharp and carried.

DR. LITTLETON: The pension plan has been carried. I wish a motion to the effect that a committee be appointed to get information on three possible plans, namely, (1) social security, (2) insurance, (3) a bank system.

MR. KELSEY: I move that the Finance Committee investigate and report.

MR. FLINT: Mr. Sullivan, Mr. Tefft, and Dr. Purdy are in Columbus and Mr. Hansen is in Cleveland. They are all close together and could look up banking contacts, insurance programs, and social security. I believe that if this were referred to the Finance Committee, partly because they must decide what we can afford for expenditures, they could be given instructions to collect information, a possible future outlay on the plan and the three variable plans, and what the cost of each would be. It seems that this could be done quite simply and very directly.

DR. LITTLETON: A committee should be appointed to advise The Society or the Trustees as to the most desirable form of pension plan. I appoint Mr. Hansen, Chairman of the Finance Committee, Mr. Sullivan, and Mr. Tefft.

Agenda Item 8, Allocation of Duties to Vice-President

This was discussed, but no action was taken.

MR. SHARP: Item 9, Election of Officers by the Board of Trustees, should be discussed with Item No. 8.

DR. LITTLETON: In the Physical Society, the Council nominates and does not elect.

MR. SHARP: The officers need not be chosen from members of the Board.

DR. LITTLETON: No. As soon as an officer is elected from the Trustees, another Trustee must be elected.

MR. COMMONS: What would happen if this year's Trustees elected next year's officers?

DR. LITTLETON: There would be another nomination by the Divisions for Trustees. The important thing to remember is that efficient officers are needed. No matter what form is followed, some will kick about it. We would get better officers if they were elected by the Board.

DR. LILLIE: Is the Board a better nominating committee than someone chosen from the Divisions or a past member of the Board?

MR. WELLS: I feel that, in general, the officers should be nominated by the Board. The Trustees should be elected as they are now.

MR. SHARP: Why not have the largest number of votes for President and the second largest number for Vice-President? There would be no question of succession the following year. He might again be Vice-President and a new President elected instead of the succession of Vice-President to President.

DR. LITTLETON: If Item 9 is approved, Item 8 is not necessary. The purpose of Item 8 is mainly to train a man for Vice-President. We have had Presidents who were not Vice-Presidents. There should be an amendment to the By-Laws.

DR. MOREY: I make the motion that the Rules Committee be requested for a proper amendment to the By-Laws providing that the nomination of officers be made by the elected Board of Trustees instead of by the two nominating committees.

The motion was seconded by Dr. Russell and carried.

Agenda Item 11, Employment Service in *The Bulletin*

DR. LITTLETON: This was brought up yesterday. Was there a decision?

MR. FLINT: Allocate a page in *The Bulletin* to various schools.

DR. LITTLETON: Suppose you list ceramic schools, personnel manager, names and addresses, etc. This would tell them whom to write to, and it could be run free of charge.

MR. COMMONS: This is done by the American Chemical Society.

DR. PURDY: Not free.

MR. COMMONS: At a nominal rate of 25¢.

DR. PURDY: We are not that low.

MR. GREENE: How about the student members of The Society giving them a break?

PROFESSOR WHITTEMORE: The boys do not want their names put on like that. Why not put the name of the school and the head of the Department on the page devoted to this in *The Bulletin*?

DR. LILLIE: That puts the initative on the employer. The man would like the chance to tell of his qualifications.

MR. COMMONS: The company might want a man of that type. The application is put in the files and the man who has a known connection and has sent in the application has a better chance to get the job than one without personal contact. There is no other method of getting contact. Take those whose applications are on file and avail-

able. Give the man a chance to use his initiative; he does not have the handicap of knowing the employer.

DR. MOREY: What is the rate?

DR. PURDY: $1.10.

MR. FRAZIER: The Pennsylvania State College puts out a bulletin with the graduating class.

PROFESSOR WHITTEMORE: The Virginia Polytechnic Institute also sends them out. The boys finance a portion and the school finances a portion. They are sent out to companies who may want a man.

MR. FLINT: Colleges provide our biggest source of supply of new members. I think it a good idea for The Society to underwrite one page so that the colleges can be listed and the data made available. People would look at it, and it would be a fine way of helping the men.

DR. PURDY: Give the page to the Ceramic Educational Council.

MR. FLINT: That is a good hunch.

Mr. Flint made the motion that one page of *The Bulletin* be given to the Ceramic Educational Council to use as they see fit.

The motion was seconded by Mr. Campbell and carried.

	Members	Non-members
University of Alabama (1940 graduates)	1	1
Georgia School of Technology (1939 and 1940 graduates)	9	5
University of Illinois (complete from 1908 through 1941)	191	247
Iowa State College (1910 through 1941)	52	67
Mass. Institute of Technology (1939 through 1941)	13	2
Missouri School of Mines (list of graduates not members of The Society prior to 1937 and 1939 and 1940 graduates)	8	27
Montana School of Mines (1939 graduates)	3	0
N. Y. State College of Ceramics (complete)	176	323
University of North Carolina (complete)	55	45
Ohio State University (complete)	291	197
Pennsylvania State College (1928 through 1941)	40	52
Rutgers University (complete)	46	71
University of Saskatchewan (beginning through 1938)	7	4
Virginia Polytechnic Institute (1939–1941)	13	10
University of Washington (complete)	35	18
West Virginia University (1940 graduates)	0	32

DR. PURDY: The Board must pass on the budget of the Institute of Ceramic Engineers. (See page 6 of *The Bulletin*, January, 1942.)

PROFESSOR WHITTEMORE: I make a motion that the budget for the Institute of Ceramic Engineers be accepted.

The motion was seconded by Mr. Wolfram and carried.

DR. LITTLETON: Concerning the Fellows Fund: Do we pay the same interest that we get out of it?

DR. PURDY: No, we pay more.

DR. LITTLETON: It is costing us 2% to carry them. This does not seem right.

MR. SHARP: It is all wrong.

MR. WELLS: I move that the practice of paying interest to the Fellowship Fund held in reserve by The American Ceramic Society be discontinued and the Dean of the Fellows so notified.

This was seconded by Mr. Flint and carried.

Agenda Item 12, Modification of System of Accepting and Grading papers for *The Bulletin* and *The Journal*

DR. LITTLETON: Is there any objection to this system which is being carried out according to intent?

This subject was discussed at length.

DR. LITTLETON: We cannot settle it, it seems, but the difficulties have been aired. Our present system is not satisfactory but it can be improved. Instruction to the Board will be sufficient for this particular time.

MINUTES OF FINANCE COMMITTEE MEETING

Held December 23, 1941, at the executive offices of The American Ceramic Society, Columbus, Ohio.

(1) The advertising rate schedule was discussed from the standpoint of increasing rates. In view of the fact, however, that most of the contracts now in effect are contracted for through the major part of 1942 and owing to the feeling that business conditions may be such as to tempt advertisers to discontinue space if a raise is made, further discussion was tabled until the time of the Annual Meeting in Cincinnati.

(2) Because of a probable decrease in The Society income during 1942, a request emanating from the Executive Committee meeting in Corning, N. Y., for a budget allowance of $1000 for a membership prospectus was rejected.

It is recommended that the Membership Committee consider the idea of using a reprint of the Annual Meeting program as a prospectus or sample of what The Society has to offer to members. This suggestion was made because it would be not only effective but also available at a minimum expense.

A budget allowance of $350 was made to cover the prospectus item, this being included in the item of office expense—secretary.

(3) A lengthy discussion was held on the matter of a suitable retirement or pension plan for Society employees.

U. S. Government Social Security was discussed, and Mr. Tefft questioned our legal status in not already being under Social Security. Mr. Sullivan will check regarding this.

Retirement annuity plans were also discussed, to be handled by a recognized insurance company and to be available at the option of the employee. The Society would pay half the cost and the employee half the cost. Pertinent age data were secured. Mr. Hansen and Mr. Sullivan will check regarding available plans and bring them up for discussion at the next meeting.

(4) The probable loss of revenue by the loss of foreign members and subscriptions was discussed. This could amount to approximately $4700 per year, but it is hoped to be not more than $1800 or $2000.

(5) In view of the probable decrease in funds during 1942, no increased budget allowance was recommended for traveling expenses of officers to Local Sections and Student Branches.

(6) The present salary schedule was discussed and raises were recommended for employees in the lower brackets.

(7) The budget requirements for 1942 were discussed, and recommendations are given in the following table. Comparisons are made with the 1941 budget and 1941 actual expenditures to date.

	1941		
	Budget	Actual	1942
Cost of printing	$20,000.00	$20,662.03	$20,000.00
Office expense: Editor	800.00	1,106.04	800.00
Abstracts	900.00	833.80	900.00
Office expense: Secretary	1,700.00	1,591.17	1,950.00
Salaries	18,460.00	18,547.25	20,460.00
Postage	1,400.00	1,674.10	1,600.00
Office rental	960.00	960.00	960.00
Office equipment	300.00	297.17	500.00
Divisional expense	200.00	29.27	200.00
Traveling	600.00	440.00	600.00
Contingent fund	200.00	193.69	200.00
President's expense	200.00	41.15	200.00
	$45,720.00	$46,375.67	$48,370.00

The items of cost of printing, Editor's office expense, and abstracts remain unchanged. The item of $1950 to the Secretary's office expense is actually a decrease to

$1600 as compared with $1700, as this item includes the $350 allocated for the membership prospectus. The salaries item is larger, and postage allowance has been increased in view of the fact that there are more manuscripts, copies, etc., being handled by mail rather than by express as in the past. Express formerly came out of the Secretary's office expense item. Office rental remains unchanged, and the office equipment allowance is larger, in view of the critical need for two new desks and typewriters. Other amounts in the budget remain unchanged.

(8) The printing and editor expense, as well as a large part of the salaries, represents the major part of the budget. Any decreases in the budget to conform with reduced revenue of future years will have to be made in these items.

It is our understanding that under our present editorial policy the acceptance or rejection of papers for publication, as well as length of the paper to be published, lies almost entirely in the hands of the Division editorial committees and that the Editor's office does not have the authority to reject papers, cut them down in length, eliminate illustrations, etc.

It is recommended that consideration should be given to a revision of our publication policy so that the amount of material to be printed may be curtailed by the Editor's office when, as, and if this becomes necessary.

Signed by the Finance Committee of The American Ceramic Society: J. E. HANSEN, *Chairman;* C. FORREST TEFFT, and JOHN D. SULLIVAN

MATERIALS AND EQUIPMENT DIVISION NOMINATIONS FOR 1942–1943

Trustee: J. E. EAGLE, Vitro Mfg. Co., Pittsburgh, Pa.
Chairman: J. F. MCMAHON, New York State College of Ceramics, Alfred, N. Y.
Vice-Chairman: E. M. RUPP, 58 Fallis Rd., Columbus, Ohio.
Secretary: J. R. KAUFFMAN, Allied Engineering Co., 29 Highland Dr., Milltown, N. J.

ART DIVISION MEETING

The spring meeting of the Art Division will be held on May 8 and 9 at the Philadelphia Art Alliance, Philadelphia, Pa.

Tentative plans for the program include (1) talks by Waylande Gregory, New York, N. Y.; Katherine Nelson, New York State College of Ceramics, Alfred, N. Y.; and George Howe, Philadelphia, Pa., (2) a luncheon, and (3) a trip to the Philadelphia Museum and a gallery talk on Pennsylvania Dutch ceramics. The Ceramic Department of the Philadelphia Museum School of Industrial Art will also be open to visitors.

The meeting of the Division has been planned to coincide with the Philadelphia showing of the selected group of Western Hemisphere ceramic ware which was on display last autumn at the Tenth Annual National Ceramic Exhibition at the Syracuse Museum of Fine Arts, Syracuse, N. Y.

PLANNED SYMPOSIUM ON TESTING AND CLASSIFICATION OF BALL CLAYS

Most whiteware producers recognize the need for the development of standardized tests for ball clays and for the determination of the relationships between the fundamental physical or chemical properties and the effects manifest during manufacture and in the manufactured product as a result of the ball clay or clays used. The Research Committee of the White Wares Division has accordingly assumed the testing and classification of ball clays as its major project.

This project was not selected in an attempt to condemn or to promote the use of any particular ball clay or to evaluate the clays of different ball-clay producers, but it is a real attempt to clarify the testing and selection of one of our most important raw materials. A successful solution of this problem would be of inestimable value to ball-clay consumers and would, in all probability, eventually prove beneficial to the producers as well.

To reach a successful conclusion, the Committee must have the cooperation of the consumers and producers of ball clays and the help of the various governmental and other large research organizations and of university departments. It is planned that this project will be a major one for the several years required and that, under the direction of the Research and Program Committees, progress symposia will be held as warranted.

In accordance with this plan, an inaugural session has been scheduled for the forthcoming Annual Meeting with a tentative outline as follows:

I. Introduction. A discussion of the present situation regarding the selection and use of ball clays.
II. A table of information compiled from the results of a questionnaire sent to ball-clay producers.
III. A general discussion of the evidence disclosed by the data compiled in II.
IV. Ball clays from the consumer's viewpoint. A general discussion in which the manufacturers will discuss ball-clay problems from their experiences in their particular industries. There should be at least two representatives from each of the following whiteware groups: high- and low-tension electrical porcelain, vitreous and semivitreous dinnerware, sanitary ware, and wall and floor tile.
V. A plan of the Research Committee for the classification of ball clays. (1) The fundamental characteristics of ball clays which determine their properties; (2) ball-clay test methods: (*a*) outline of methods currently used and (*b*) discussion and suggestions by members; and (3) classification of ball clays by means of fundamental and physical test data.
VI. Technical testing and test methods for ball clays. This will consist of the comments and suggestions of at least five persons familiar with such procedure.
VII. A general discussion of the research plan.

All who are interested in any phase of this subject are encouraged to attend the Annual Meeting and take an active part in the discussions, for it is only through such cooperation that the Research Committee can function successfully.

MANUAL OF STANDARD TESTS AND SPECIFICATIONS OF THE WHITE WARES DIVISION

The Standards Committee of the White Wares Division of The American Ceramic Society is attempting to revise, modernize, and enlarge the scope of standards and tests as published by The Society in the June, 1928, issue of *The Journal.* The present sources of tests and standards as applied to whiteware are (1) The American Society for Testing Materials, (2) federal and state specifications, (3) trade associations, and (4) White Wares Division Standards (June, 1928).

It is not the policy of the Committee to formulate specifications for manufactured products where none exist at present. There is need, however, for the formulation of specifications for a great many of our raw materials and for the standardization of test methods as applied to materials and products.

The Committee fully realizes that such a project as this cannot be successfully completed by a small group of men but by the cooperative efforts of a large number of interested members.

The following outline of tests and specifications indicates the scope of the work. A great many members of the Division have been invited to assume the task of writing certain sections that are to appear in the Manual of Standard Tests and Specifications of the White Wares Division of The American Ceramic Society.

—Standards Committee of the White Wares Division:

J. R. Beam, G. A. Bole, W. H. Earhart, R. F. Geller, C. G. Harman, J. H. Koenig, F. H. Norton, Edward Schramm, Harry Thiemecke, J. W. Whittemore, and F. P. Hall, *Chairman*

OUTLINE OF MANUAL*

I. General (F. H. Norton). A, atomic weights; B, common ceramic materials with chemical formulas; C, standard scales for testing sieves; D, symbols for heat and thermodynamics; E, gaseous, liquid, and solid fuels.

II. Whiteware Formulas (A. S. Watts). These will include compositions of glazes and bodies for semivitreous ware, chinaware, electrical porcelain, sanitary ware, tile, etc.

III. Definitions of Raw Materials (J. W. Whittemore and J. L. Austin).

IV. Raw Materials Tests. A, sampling; B, physical tests: (1) fineness, (2) water of plasticity, (3) pore water, (4) apparent specific gravity, (5) bulk specific gravity, (6) slaking test, (7) absorption and porosity, (8) dry shrinkage, (9) fired shrinkage, (10) flexural strength, (11) P.C.E., (12) exchangeable bases, (13) base-exchange capacity, and (14) pH determination; C, chemical tests. (W. H. Earhart and J. H. Koenig have been assigned all the raw materials tests except A, sampling, and C, chemical tests, which have not been assigned as yet; (12) exchangeable bases will be written by W. W. Meyer.)

V. Raw Materials Standards and Specifications A, feldspar, and B, flint (R. C. Burgess); C, whiting (not assigned); D, clay (S. C. Lyons); E, talc (Donald Hagar); F, pyrophyllite (Robert Sherwood); G, nepheline syenite (C. J. Koenig); H, dolomite and I, plaster (J. E. Wise).

VI. Process Control Tests (not assigned). A, dry-press: (1) semiplastic, (2) dry-press; B, casting process; C, jiggering; D, extrusion and turning.

VII. Body Tests (R. F. Geller). A, expansivity; B, translucency; C, absorption; D, tensile strength; E, flexural strength; F, compressive strength; G, impact strength; H, elasticity; I, heat-shock test; J, moisture expansion.

VIII. Glaze Tests. A, glaze fit (H. G. Schurecht); B, chemical durability (R. F. Geller); C, hardness (J. H. Koenig); D, glaze warpage (Donald Hagar); E, glaze-slip control (C. G. Harman).

IX. Tests Applied to Manufactured Products. A, general (A. S. Watts); B, tableware: (1) vitreous (Edward Schramm); (2) semivitreous (G. A. Bole); C, electrical insulators: (1) high-tension porcelain and (2) low-tension porcelain (E. H. Fritz and Ralston Russell, Jr.), (3) spark-plug porcelain (F. H. Riddle), (4) radio insulators and (5) radio capacitors (Louis Navias; outline on p. 34, this issue); D, sanitary ware: (1) vitreous (J. R. Beam), (2) semivitreous (H. Whittaker); E, chemical porcelain (H. W. Ryland); F, chemical stoneware (not assigned); G, tile: (1) vitreous and (2) semivitreous (J. R. Kauffman); H, refractory ware: (1) vitreous and (2) semivitreous (J. D. Harnish).

X. Specifications for Manufactured Products. A, general (not assigned); B, tableware: (1) vitreous (Edward Schramm), (2) semivitreous (G. A. Bole); C, electrical insulators: (1) high-tension (R. Russell, Jr.), (2) low-tension (not assigned), (3) spark-plug porcelain (F. H. Riddle), (4) radio insulators and (5) radio capacitors (Louis Navias; outline given below); D, sanitary ware: (1) vitreous (J. R. Beam), (2) semivitreous (H. W. Whittaker); E, chemical porcelain (not assigned); F, chemical stoneware (not assigned); G, tile: (1) vitreous and (2) semivitreous (H. Z. Schofield); H, refractory ware: (1) vitreous (J. D. Harnish), (2) semivitreous (not assigned).

*Names of persons writing sections appear in parentheses.

TESTS AND SPECIFICATIONS FOR RADIO INSULATORS AND CAPACITORS

The following outline of specifications for radio insulators and capacitors and the outline of tests on p. 34 have been assembled by Louis Navias of the General Electric Co., Schenectady, N. Y., for the Standards Committee of the White Wares Division (see preceding Outline of Manual of Standards Tests and Specifications of the White Wares Division of The American Ceramic Society). These specifications will probably be adopted as standard by the White Wares Division, although some changes may be made before the final adoption is approved.

X. Specifications for Manufactured Products. (C) Electrical Insulators; (4) Radio Insulators*

	U. S. Navy specification RE-13A 317 F		U. S. Army specification 71-229-D	
	(Grade F)	(Grade G)	(Grade F)	(Grade G)
(1) Water absorption	S.N.E.† 0.1%	S.N.E. 0.1%	S.N.E. 0.1%	S.N.E. 0.1%
(2) Dye penetration test				
(3) Tensile strength			>4000 p.s.i.‡	>6000 p.s.i.‡
(4) Compressive strength			>40,000 p.s.i.‡	>60,000 p.s.i.‡
(5) Flexural strength (modulus of rupture)			>10,000 p.s.i.‡	>15,000 p.s.i.‡
(6) Bending				
(7) Resistance to impact (Charpy)				
(8) Thermal shock			Required no. of cycles	
(9) Dielectric strength (commercial power frequencies usually 60 cycles)			>200 volts/mil for specimen 1/8 in. thick	
On test samples				
(10) Dielectric constant	Loss factor (%) 300 kc.		Loss factor (%) 1 mc. (avg. of 3 specimens)	
(11) Power factor				
(12) Loss factor	S.N.E. 7.0	S.N.E. 1.0	S.N.E. 7.0	S.N.E. 2.0
			Individual specimen	
			Max. 9.0	Max. 3.0
(13) Wet-surface leakage test				
(14) Tolerances				

* No data have been given for U. S. Coast Guard specification RIS-258-A and for Civil Aeronautics Authority specifications.

† S.N.E. = shall not exceed.

‡ On 5 specimens; no single specimen to have <80% of required avg.

X. Specifications for Manufactured Products. (C) Electrical Insulators; (5) Radio Capacitators
No specifications have so far been written for Radio Capacitors.

NEW MEMBERS FOR JANUARY

Personal

BALINKIN, ISAY A., Univ. of Cincinnati, Cincinnati, Ohio; assistant professor.

BEASLEY, DENNIS R., 121 Woodland Ave., Clarksburg, W. Va.; chemist, Akro Agate Co.

BERGMANS, CARL, Continental Faience & Tile Co., South Milwaukee, Wis.; president.

BUTTERS, PHILIP W., Company D, 53rd Medical Training Bn., Camp Barkeley, Tex.

COLE, GROVER D., 2106 Wallingford Rd., Ann Arbor, Mich.; instructor, Univ. of Michigan.

DUNN, HOLBERT E., Vanadium Corp. of America, Bridgeville, Pa.; chemical engineer.

DURGIN, CHARLES B., Monsanto Chemical Co., Anniston, Ala.; assistant director of research.

EVANS, R. E., 721 West Warren Ave., Youngstown, Ohio; Standard Lime and Stone Co.

GREENWOOD, J. I., Consolidated Edison Co. of New York, Inc., 4 Irving Place, New York, N. Y.

HARRINGTON, HENRY W., 757 Chenango St., Binghamton, N. Y.; ceramic engineer, Solvay Process Co., Syracuse, N. Y.

KREHBIEL, FREDERICK H., 88 Lincoln Ave., Pataskala, Ohio; vice-president, Accurate Pyrometric Cone Co.

PAVLISH, ARNOLD E., 1420 Meadow Rd., Columbus, Ohio; research engineer, Battelle Memorial Institute.

PRIESTLEY, JOSEPH E., "Desia," Haggstones Rd., Worrall, Sheffield, England; production manager, Thomas Marshall & Co. (Loxley), Ltd.

RAMMER, HYMAN L., Box 780, Stockton, Calif.; chemist, Boxboard Products.

SMITH, J. TALBOT, 1540 Scott Ave., Chicago Heights, Ill.; ceramist, Kimble Glass Co.

STOVEL, J. H., Canada China Clay & Silica, Ltd., Lac Remi, Quebec, Canada (membership formerly in name of John A. Dawson).

SWEARINGEN, J. C., Hazel-Atlas Glass Co., Zanesville, Ohio.

TERRY, JOHN H., JR., Golding-Keene Co., Keene, N. H. (membership formerly in name of Charles E. Golding).

THORNTON, R. ALLAN, JR., Whitall-Tatum Div., Armstrong Cork Co., Millville, N. J.; laboratory technician.

VAN ETTEN, CHARLES L., 105 East 9th Ave., Homestead, Pa.; Harbison-Walker Refractories Co.

Student

University of Illinois: CHARLES J. STALEGO.

New York State College of Ceramics: LE ROY GREENSPAN.

North Carolina State College: RICHARD DAMMANN, RUFUS J. SMITH, JR., WILLIAM J. WHITENER, EDWARD L. WOODALL, JR.

University of Texas: BRUCE BLOUNT.

Virginia Polytechnic Institute: HEYWOOD J. KNIGHTON.

University of Washington: JAMES J. GANGLER, HARVEY L. TIBBALS.

ROSTER CHANGES DURING JANUARY*

BRADWELL, CYRIL, A. P. Green Fire Brick Co., Ltd., Commercial St., Leaside, Toronto 12, Ontario, Canada (Mexico, Mo.)

BRETZ, LEWIS A., American Vitrified Products Co., East Liverpool, Ohio (East Canton, Ohio)

CARTER, HERBERT D., 3351 Dorchester Rd., Shaker Heights, Ohio (Canton, Ohio)

DAVIS, H. E., New Castle Refractories Co., Newell, W. Va. (South Amboy, N. J.)

EVERLY, GEORGE B., 382 W. Pine, Canton, Ill. (Los Angeles, Calif.)

GENTSCH, B. F., Oakfield, N. Y. (Fort Bragg, N. C.)

HAHNER, CLARENCE H., 7202 Harwick Rd., Woodacres, Md. (Arlington, Va.)

HANKS, CHARLES F., Porcelain Div., Westinghouse Electric & Mfg. Co., 1466 Powell St., Emeryville, Calif. (East Pittsburgh, Pa.)

IRWIN, PHILIP P., 731 Green Lane, East Liverpool, Ohio (Carrollton, Ohio)

JACKSON, ARTHUR W., Harbison-Walker Refractories Co., Athens, Tex. (Fairfield, Ala.)

KAUTZ, KARL, 754 Rotch Ave., N. E., Massillon, Ohio (Burgettstown, Pa.)

KNECHT, ALBERT O., 2210 E. Main St., Springfield, Ohio (Camden, N. J.)

LEE, HARLEY C., Box 1150, Las Vegas, Nev. (Columbus, Ohio)

MCCOLLOM, PERRY C., New Castle Refractories Co., Box 230, New Castle, Pa. (Carteret, N. J.)

MOHR, WILLIAM C., 1002 South Ave., Wilkinsburg, Pa. (Derry, Pa.)

OTTOSON, AXEL C., 204 Ceramics Bldg., Univ. of Illinois, Urbana, Ill. (Bellaire, Ohio)

PESKIN, WILLIAM L., 73 Crittenden Blvd., Rochester, N. Y. (Elizabeth, N. J.)

PINNOW, HARLEY R., 121 Second Ave., Derry, Pa. (Wilkinsburg, Pa.)

PITTENGER, JOHN T., 9 Park Place, Princeton, N. J. (Newell, W. Va.)

ROSSELL, H. A., West Paris, Maine (Joplin, Mo.)

RUPRECHT, BERTRAM C., 4719 Barlind Dr., Pittsburgh (10), Pa. (Homestead, Pa.)

SHEAROUSE, LEE A., 2nd Provisional Ordnance Training Co., Aberdeen Proving Ground, Md. (Atlanta, Ga.)

SMITH, HILLARD A., John Douglas Co., Cincinnati, Ohio (Metuchen, N. J.)

THOR, MURNER E., 1711 Wellesley Dr., Santa Monica, Calif. (Moline, Ill.)

VINCENT, GEORGE L., 134 W. Wright St., Milwaukee, Wis. (Rockville Center, N. Y.)

WASHBURN, C. ELDYN, 16 Bloomingdale Ave., Cranford, N. J. (Rutherford, N. J.)

ZINSZER, WILLIAM K., Apt. 8, 555 Forest Ave., Palo Alto, Calif. (Chicago, Ill.)

* Address in parentheses is former address.

MEMBERSHIP WORKERS' RECORD

Personal			
T. M. Arnold	1	J. H. Chesters	1
J. D. Baker	1	T. K. Cleveland	1
R. E. Birch	2	H. O. Krehbiel	1
Richard Brian	1	F. R. Matson	1
G. H. Brown	1	H. R. Pinnow	1
Office		9	
Student			
A. I. Andrews	1	J. A. Pask	2
A. F. Greaves-Walker	4	F. K. Pence	1
M. E. Holmes	1	J. W. Whittemore	1
		Grand Total	**30**

LOCAL SECTION NEWS

PITTSBURGH SECTION

1942 Meetings

C. B. Mershon, industrial sales manager, Manufacturers' Light & Heat Co., Pittsburgh, Pa., spoke on "Gas Burning and Control Equipment for the Ceramic Industries" at the meeting of the Section held on January 13. He discussed types of gas installations and their applications and limitations and described briefly the automatic controls now available for industrial kiln firing.

The programs for the next six months are completed and the new officers of the Section are looking forward to another interesting year (for 1942 officers, see December, 1941, *Bulletin*, p. 459).

A Symposium on Particle Sizing and Packing was presented at a meeting held on February 10.

—R. M. SHREMP, *Secretary*

NORTHERN CALIFORNIA SECTION

The Northern California Section has elected the following officers for 1942:

Chairman: G. A. PAGE, Stockton Fire Brick Co., Pittsburg, Calif.

Vice-Chairman: W. V. BRAGDON, California Faience Co., Berkeley, Calif.

Secretary: B. W. WYATT, N. Clark & Sons, Alameda, Calif.

Treasurer: W. C. HILDEBRAND, L. H. Butcher Co., San Francisco, Calif.

CENTRAL OHIO SECTION

A meeting of the Central Ohio Section was held on January 23, 1942, at the Engineering Experiment Station, Ohio State University, Columbus, Ohio. In the afternoon, Albert Prebus of the University faculty discussed the operation and uses of the electron microscope.

Following dinner at the Southern Hotel, J. H. Koenig, Hall China Co., East Liverpool, Ohio, gave an illustrated talk on glazes.

Entertainment was provided by the Ceramic Quartet.

—C. J. KOENIG, *Chairman*

MICHIGAN-NORTHWESTERN OHIO SECTION

A dinner meeting of the Michigan-Northwestern Ohio Section was held on January 16, 1942, at Gordon's Grill in Mt. Clements, Mich.

Ross C. Purdy, General Secretary of The American Ceramic Society, was the featured speaker.

Affiliation with Engineering Society of Detroit

The Michigan-Northwestern Ohio Section for over two years has been affiliated with the largest local engineering society in the world, the Engineering Society of Detroit.

This society, founded in 1936 and endowed with $500,000 from the Horace Rackham Foundation, has grown rapidly to its present membership of over 2500 engineers. It has recently received an additional endowment of $1,750,000, most of which has been used to build a beautiful and well-equipped building which occupies a full block south of the Art Institute and across the street from the Main Library. One wing houses the E.S.D.; the other wing houses the University of Michigan Extension Service.

A program of cooperation with engineering and technical societies was begun early in the history of E.S.D. Any local section of a national society could become an affiliate if 15% of the section's membership were also members of E.S.D.

The affiliate council, which has considerable weight in determining the policy of E.S.D., is comprised of two representatives from each of the affiliate societies. The Michigan-Northwestern Ohio Section of approximately forty members has equal voice with larger sections such as the Society of Automotive Engineers, which has about 1100 members (the total membership of affiliate societies is 4600), and one of its representatives, F. H. Riddle, has been honored in being elected vice-chairman of the affiliate council.

The Section has helped in such joint undertakings as contributing to the cost of the Census of Technical Manpower undertaken by E.S.D. and which has canvassed about 12,000 engineers around Detroit. As individuals, members of the Section are serving on committees of E.S.D. Each year, the Society sponsors an educational guidance program for high-school seniors interested in learning more about the various fields of engineering. The American Ceramic Society is always represented by councilors who talk with the boys interested in ceramics.

The Section feels that it has gained much from its affiliation with E.S.D. and that it has, in spite of its size, a definite part in the program of this splendid organization.

—A. R. DECKER, *Secretary*

INSTITUTE OF CERAMIC ENGINEERS

Executive Committee

President: E. H. FRITZ, Westinghouse Electric & Mfg. Co., Derry, Pa.

Vice-President: H. M. KRANER, Bethlehem Steel Co., Bethlehem, Pa.

Secretary: H. B. DUBOIS, Consolidated Feldspar Corp., Trenton, N. J.

Past-President and Trustee Representative: H. G. WOLFRAM, Porcelain Enamel & Mfg. Co., Baltimore, Md.

Past-President: A. F. GREAVES-WALKER, Dept. of Ceramic Engineering, Univ. of North Carolina, Raleigh, N. C.

NEW MEMBERS

Member Grade

RALPH K. DAY, Spencer Lens Co., 19 Doat St., Buffalo, N. Y.

J. EARL FRAZIER, Frazier-Simplex, Inc., 436 E. Beau St., Washington, Pa.

R. H. TURK, Porcelain Enamel & Mfg. Co., Baltimore, Md.

Associate Member Grade

B. M. BURCHFIEL, 1153 Ruberta Ave., Glendale, Calif.
PAUL T. TALBOTT, 2175 N. Star Ave., Columbus, Ohio
EDMUND JONES, JR., 2840 Ewald Circle, Detroit, Mich.
EARL A. SOLOMON, 32 Sickmon St., Hamburg, N. Y.

Advancements to Associate Member Grade

E. L. PHILLIPS, Box 17, Tyrone, Pa.
NORMAN SCHOEPPEL, 417 E. Jackson St., Mexico, Mo.
S. LEWIS SANTOMIERI, 50 Wilson Ave., Columbus, Ohio.

MEETING WITH INDUSTRIAL MINERALS DIVISION, A.I.M.M.E.

The Industrial Minerals Division of the American Institute for Mining and Metallurgical Engineers held its autumn meeting in Rolla, Mo., from October 23 to 25 in cooperation with the Missouri Industrial Conference, the Institute of Ceramic Engineers, The American Ceramic Society, the Missouri Geological Survey, and the Missouri School of Mines and Metallurgy.

Magnesium refractories and supplies were discussed at the General Session. The first paper, "The Comparative Status of the Production of Magnesium Oxide from Natural Magnesite and from Sea Water," was presented by Max Y. Seaton, United Chemicals, Inc., New York, N. Y. Mr. Seaton stated that magnesium oxide was used, in order of importance, for (1) dead-burned magnesite for the construction and maintenance of the hearths of basic open-hearth furnaces and for the production of magnesite brick, (2) caustic calcined magnesia for the formulation of oxychloride cements, (3) fertilizers, and (4) the production of metallic magnesium which is in demand for defense production.

Natural magnesite is found chiefly in this country in the amorphous magnesites of California, the crystalline magnesites of Washington and Nevada, and the brucite deposits of Nevada. Dolomite is also an important potential source of magnesia. Underground brines of Michigan, Ohio, and West Virginia, as well as sea water, are the other sources of magnesium. Although sea water has only 0.21% of MgO concentration, it represents an immense reserve. The Northwest Magnesite Company is now building a plant at Cape May, N. J., for the recovery of magnesia from sea water. Natural magnesites are the chief source of magnesium oxide at the present time, but improved methods of recovering MgO from sea water make it a rapidly increasing source.

Magnesia has been made for a number of years from sea-water bittern, the product remaining from the concen-

tration of salt or sodium chloride from sea water. The bittern contains about 12.5 to 16.0 NaCl, 6.0 to 8.7 $MgCl_2$, 4.2 to 6.1 $MgSO_4$, 1.4 to 1.9 KCl, and 0.14 to 0.2% $MgBr_2$. To produce a satisfactory magnesium hydroxide from the bittern by precipitation with lime, the magnesium sulfate must be removed by recycling a portion of the calcium chloride (the end product of the reaction between magnesium chloride and lime), mixing this calcium chloride with sulfate-containing bittern, and thus precipitating the sulfates as gypsum. The remaining bittern is mixed with powdered quicklime, each gram of which becomes the center of a spongelike mass of magnesium hydroxide. The resultant sludge shows the following calcined analysis: 0.7 SiO_2, 0.2 Fe_2O_3, 0.3 Al_2O_3, 1.5 CaO, and 97.3% MgO. This sludge is filtered and either calcined at high temperatures for refractory use or lightly calcined for use as oxychloride cements.

The paper on "Basic Refractories" by H. P. Eells, Basic Dolomite, Inc., Cleveland, Ohio, could not be given because of his absence. W. J. McCaughey, Ohio State University, Columbus, Ohio, took his place and reviewed the place of loose magnesia and bonded magnesia refractories in the open-hearth furnace. He also discussed the limitations of magnesia refractories and the causes for their failure when in contact with the slags of the open-hearth furnace.

Alvin Schallis, assistant mineral economist, U. S. Bureau of Mines, presented details concerning the known reserves of magnesium-bearing minerals of the United States in his paper entitled "Dolomite as a Source of Magnesia and Magnesium."

A round-table discussion on future sources of magnesia followed the General Session. It was brought out that although sea water and dolomite represent future sources of magnesia of industrial importance, natural magnesite seems to be the chief future source.

After the round-table discussion, Mr. Houston and Mr. Rankin of the Tennessee Valley Authority, Knoxville, Tenn., presented a paper entitled "Forsterite Olivines of the Tennessee Valley Region as a Source of Magnesium Salts and Metal." They stated that enormous tonnages of serpentine and olivine are present in Tennessee. The process briefly entails crushing the pure raw materials, attacking with acid to remove the magnesium content, and precipitating with the appropriate reagents.

The first Technical Session was devoted to bauxite and diaspore. A round-table discussion on "Future Sources of Aluminum" was held at the end of this session. The chief future source of aluminum is bauxite, inasmuch as the supply of diaspore is limited and it is difficult to treat for aluminum.

During the second Technical Session, a paper was presented by John Conley, chemical engineer, U. S. Bureau of Mines, College Park, Md., on "Lightweight Aggregates from Slate Waste." He stated that the slate industry has shown a decided decrease in the last twenty-five years, inasmuch as composition roofing has replaced slate as roofing material to a great extent. Expanded slate aggregates are used in the manufacture of concrete, building blocks, and roofing tile. Slates which show a volume increase of from three to seven times upon heating are the most desirable. The expansion takes place at right angles to the cleavage plane. The specific gravity of the expanded slate varies from 0.52 to 0.82; it costs $1.50 to $1.75 per cubic yard.

The last paper presented was "Relation of Permeability and Specific Gravity of Insulating Refractories" by Paul G. Herold, Leonard Stearns, and W. J. Smothers, the staff of the Ceramic Engineering Department, Missouri School of Mines and Metallurgy, Rolla, Mo. They determined the relation between permeability and other pertinent properties of insulating refractories. As bulk density is an easily determined value, it was used for the comparison.

Samples of insulating refractories and backing-up block were grouped according to their refractory value and their permeabilities and bulk densities were determined. Permeability was determined by measuring the time required for a fixed volume of air under a certain pressure to flow through each sample.

The data obtained was used to plot curves of apparent permeability against pressure. The plots, grouped according to service temperatures given by the manufacturers of the samples, showed that a straight-line relationship held for most curves. The break in the curves indicated the pressure at which turbulent flow is produced. An increase in pressure beyond these points will not cause further heat losses by gas flow through the refractories, i.e., a condition of equilibrium has been reached.

With the exception of one group, the pressure at which turbulent flow is produced decreases with an increase of service temperature and the ratio of apparent permeability to pressure tends to increase with service temperature.

The data show that the average bulk density increases with service temperature. In general, therefore, the bulk density increases as the apparent permeability increases.

WAR EMERGENCY

CONVERSION : AMERICA'S JOB

Winning the war is not only a job for fighting men, for manufacturers and workers who make weapons, and for farmers who feed us. Housewives can help by doing without that new car, that new washing machine or icebox—products which take an astonishing amount of steel and other materials now needed for war.

Our immense resources are not yet being fully used. We must convert more men and machines to war work. We must convert every remnant of our national complacency to grim realization of the job to be done.

The bulk of the initial arms orders have gone to large firms with well-known records of performance. The smaller firms are now needed, however, to work under subcontracts for larger firms, and Congress is appropriating additional billions to spread the work more widely than ever before.

To bring the little men and prime contractors together, the War Production Board is operating Contract Distribution offices in one hundred and thirteen widely placed cities. These offices do not sign contracts, but they steer factory owners to Army and Navy procurement offices and to prime contractors who can.

Some problems of conversion are peculiar to a particular industry and extend throughout that industry. Manufacturers within each such industry may discuss these problems together through their industry branches in the Division of Industry Operations of the War Production Board at Washington. One of the functions of this Division is to determine which firms shall continue with necessary civilian production and which shall convert to war work.

Subcontracting brings the work to the worker, eliminating or alleviating many problems of housing and transportation in congested communities around the large mass-production plants. Similarly, many potential ghost towns and the construction of much machinery with little peacetime utility will be avoided by this policy of using existing equipment where it stands.

Thus millions of workers will be enabled to continue living in their established homes. The hardships and social dangers of wholesale migrations of entire families to overcrowded communities will be immeasurably lessened.

Not all factories, however, can convert to war or essential civilian work. Some will have to shut down for lack of raw materials, and their managers and workers will have to go into other essential plants.

IMPORTANCE OF CERAMIC ENGINEERING

Every branch of the ceramic industry is today active in the defense program. The contribution of each one to the production of bombers, torpedoes, tanks, ships,

and guns is very direct and essential. Any steel master will say that the ceramic linings of his furnaces are vital factors in the quantity and quality of steel produced. The life of a steel furnace is also controlled by the quality of its ceramic lining. Steel companies employ ceramic engineers to watch the linings of the furnaces in operation and to make repairs before the wear has become serious enough to cause a shutdown and interrupt the production of the furnace.

The refractory lining of steel furnaces is not the simple clay firebrick used during the first World War. A wide variety of mineral mixtures, including silica, chrome, magnesite, diaspore, and many other refractory minerals, is now needed to produce the special alloys so essential to our war efforts.

Most of these new refractories have been developed by ceramic engineers who are especially trained in the theory and industrial application of these ceramic products. They have spent years in mastering the problems involved and are thus effectively serving the nation. The essential war industries, however, are deficient in trained ceramic engineers.

The abrasive grinding-wheel industry, whose produce has replaced the lathe in many metal-working operations, has doubled its production to meet war needs.

Glass containers must replace metal and the demands are crowding this industry to extreme production.

The demands for electrical insulators, sanitary ware, chemical ware, and household china for new war industries and their housing are crowding the capacities of these industries.

Cement, brick, sewerpipe, and innumerable other ceramic products are essential to our rapid war expansion program.

Men have been educated and have then spent years in mastering the problems of quality production. Without them the quality and quantity of production will decline. These men are undoubtedly more valuable to the nation when they are doing the essential work for which they are trained than they could be as apprentices in work for which they have had no special training or experience.

Postwar Problems

Few Americans saw or heard of the ceramic industries of France during the first World War. Many of these industries were classed as nonessentials. The workers were drafted and the plants were closed. Owing to war losses, these plants were never able to re-open and most of the French ceramic industry was lost. Germany preserved these industries and stole the markets from the French. Germany and Japan will do the same to us if we allow our ceramic industries to be demoralized by the loss of their essential technical and skilled workers. To avoid this, every person in any way interested in ceramic industrial progress should become active in the education of draft boards regarding the service and importance of the trained ceramic engineer, both as an indirect producer of war material and as an essential contributor to the maintenance of the American way of life.

With more than 4000 ceramic plants, many of which find it profitable to employ five or more ceramic engineers, and with less than 1500 ceramic engineers graduated to date, the picture of industrial needs is apparent. Furthermore, the rapid changes and developments in ceramic engineering and technology during the last fifteen years and the advance of the earlier graduates to executive positions leave only about 1000 trained men to guide production in this time of stress. We must certainly retain these men in the ceramic plants of our country.

PLACE OF TRADE ASSOCIATIONS IN NATIONAL DEFENSE

Maximum service to the National Defense program must be cooperative and concerted in nature. Such cooperation, however, cannot be complete merely by wishing it or by requesting it. It must be implemented by administrative machinery operated by experienced hands. Industry has such machinery in its trade associations, which are the product of long years of careful building.

In a time of emergency it is possible to construct new machinery to facilitate group action. It may take the form of industry committees, boards, or panels designated by a government agency. To be truly representative, however, they must represent the same groups which the associations represent. Only as far as they are nominated by the industry do they parallel the associations. Only as far as they are actually composed of members of an industry group are they generally the same as trade association representatives.

The government has been urged to use industry committees in connection with the National Defense emergency. The committees so used have given loyal, devoted, and efficient service, often at great sacrifice of time and personal attention to their respective businesses. The trade association still, however, has a potential usefulness in the present situation which has not yet been recognized.

The procedures of trade associations are always democratic, always representative of majority views, always public, always consonant with the general interest, and always within the bounds of legality insofar as they can be ascertained. They are amenable to specific instructions from government authority just as a public agency would be. Their practical advantage for usefulness in all matters relating to industry consists (1) in full-time, experienced personnel whose knowledge is of the industry as a whole and whose interest is in the industry as a whole, (2) the possession of facilities and techniques for the procurement and analysis of factual data, and (3) an established pattern of procedure which, through boards, committees, functional groups, or allied associations can explore situations or inaugurate discussions or canvass opinion.

STEEL, COPPER, AND RUBBER WASTED WHERE PORCELAIN SERVES BETTER

Open Letter from Porcelain Products, Inc.

"The Office of Production Management, in a letter dated December 27, 1941, and signed by Dean G. Edwards, Construction Branch, notified the electrical manufacturing industry of the proposed early construction of three new large cantonments in the south and southeast. The various quantities of electrical materials that will be required for these cantonments were listed and the electrical industry was notified to be ready to supply them. The bill of materials thus presented to the electrical industry includes approximately 26,000,000 ft. of armored cable which, when other items listed and not listed are considered, may be taken as evidence that the forthcoming cantonments are to be wired with armored cable or so-called "all-metal" systems.

"For reasons of simple patriotism, plus rudimentary common sense, we are impelled hereby to register a vigorous objection to this method of wiring for the following reasons:

"(1) Waste of steel: This amount of armored cable wiring involves approximately 4,420,000 lb. of steel which would otherwise be available for armaments and ordnance. The use of porcelain knob and tube wiring would save all of this steel, except for approximately 5% allowed for nails. A further substitution of porcelain outlet boxes for the steel outlet boxes now specified would save an additional 850,000 lb. of steel (O.P.M.'s own figures).

"(2) Waste of public funds: Armored cable wiring will cost more than knob and tube wiring by from 10 to 33%, depending on varying factors (statistics from recent issues of Standard Handbook for Electrical Engineers).

"(3) Waste of copper: Armored cable requires more copper than knob and tube wiring for the same current-carrying capacity (Authority: Tables Nos. I and II, 1940 National Electric Code).

"(4) Safety: The safety record of knob and tube wiring is superior to that of armored cable (Authority: records of fire rating bureaus and fire insurance companies).

"(5) Waste of rubber, cotton, and paper: Conductors run separately on porcelain knobs or through porcelain tubes

require less insulation than when they are closely confined in armored cable.

"(6) Porcelain knobs, tubes, and cleats for electric wiring involve *no critical or scarce materials* (except for the relatively insignificant quantity of nails) *and the porcelain manufacturing industry has capacity adequate to handle these requirements promptly.*

"In crowning defiance of the government's own findings on this subject, we cite the fact that the Defense Housing Critical List issued by the Office of Production Management, dated September 12, 1941, which includes proposed revisions of October, 1941, lists knob and tube wiring as the first preference for nonfireproof construction (such as cantonments). Their recommendations are based on impartial hearings, investigations, and findings of facts.

"The first reaction to this letter might be to class this complaint as a whine of disappointment from a firm having a commercial axe to grind. A certain selfish interest is admitted, but it is not admitted as the primary and basic reason for registering this complaint. The arguments cited are so fundamental in their relationships to the country's defense needs that their importance transcends any petty, selfish motives of individual manufacturers.

"When we consider the hundreds of thousands of American men and boys in the armed services in far corners of the earth, struggling desperately against overwhelming odds because of their country's delay in furnishing them the material means of defense and offense, conditions such as those discussed take on a new and disquieting perspective.

"To summarize, we object to this wholly needless additional burden on steel, copper, and rubber industries, already strained beyond capacity, while another industry, the porcelain industry, has untapped resources both able and willing to quickly take over a share of this task. We repeat—our complaint rests squarely on the basis of simple patriotism and rudimentary common sense in the efficient prosecution of the war. Intervention in behalf of this cause or at least suggestions for further procedure will be deeply appreciated."

PORCELAIN MEETS CHANGING NEEDS OF INDUSTRY

The past twelve months have placed many new demands on porcelain. There has been an increased use of interference-free insulators, the reliability of porcelain has been improved by better coordination of station insulation and by the adoption of hermetically sealed units, and a new and superior plastic has been developed which has released essential defense materials.

Conductive glaze compositions have had to be changed so that materials not vital to national defense might be used without decreasing the effectiveness or permanence of the insulators. In spite of soaring demand, materials have been found and processes adapted to them so that the product has been improved consistently. A greater margin of operating safety is assured today than a year ago.

In the light of today's heavier loads and the increased importance of complete service continuity, higher basic insulation levels and a greater ability to withstand wet, dry, and impulse characteristics have become a necessity for users of switch and bus units. This is particularly true for the 46- and 69-kv. insulators. The porcelain industry has re-designed both insulators, produced the necessary tools, and is now furnishing new units for those two voltages. Such changes in standard products are particularly significant during times like this when manufacturing capacity is at a premium.

Dependability of every service, and particularly of oil-insulated apparatus, is emphasized today more than ever before. This has put a premium on the proper sealing of the electrical terminals. The failure of a transformer or oil circuit breaker owing to moisture, dirt, or loss of insulating oil might mean a delay in vital defense production. As a result, bushings have become hermetically sealed units and are themselves soldered into the electrical devices with which they are used.

Porcelain still serves the electrical industry at the old stand. Line insulation is better than ever because the leavening of new processes and new materials has improved the performance of designs that have become as comfortably adapted to the service for which they were originally produced as an old shoe. New avenues of service have been explored and new uses for a familiar product have been perfected which displace other products more urgently needed elsewhere not by compromise but by actually doing the job better and more economically. A new service ceiling was reached in 1941. There is no reason to believe that porcelain will be confined even by that new ceiling. At least porcelain and the porcelain industry have again proved that both are still capable of making adjustments and improvements in spite of the heavy demands of rapidly expanding industry.

NO SHORTAGE IN COBALT

Before the present war, Europe was producing between 80 and 90% of all the cobalt oxide manufactured in the world; Belgium plants alone were producing approximately 60 to 70% of the world output of cobalt metal, cobalt oxide, and cobalt sulfate. After the war started, shipments of ore to the European refining plants were discontinued, and after the invasion of Belgium the largest producing units of cobalt oxide and cobalt sulfate were completely destroyed. At that time, there was probably a six- to eight-months' supply of cobalt materials located in various parts of Europe and the United States.

To supply the necessary cobalt products to industry in the United States, immediate action had to be taken to refine cobalt in this country.

The Ceramic Color and Chemical Manufacturing Co., New Brighton, Pa., recognized this condition, and plans for a cobalt refining plant were immediately drawn. Ground was broken early in the summer of 1940, and a plant was constructed at a cost of approximately $100,000. This plant went into operation in February, 1941, and today is producing approximately 20,000 lb. of cobalt oxide and 8000 lb. of cobalt sulfate per month.

The design, construction, and operation of this cobalt plant was handled entirely by *ceramic* engineers. The background of several years of experience which the ceramic engineers have had in producing colors and chemicals especially adapted for use in the ceramic industry was a tremendous advantage. Equipment was designed, installed, and operated with few changes and cobalt oxide was being manufactured at an exceptionally early date. Several tanks of 10,000-gallon capacity had to be constructed and installed. When it was necessary to use metal tanks, they were all lead lined; over fifty tons of lead were used in this process. Special Duriron valves were also necessary in this construction. When it was possible, huge cypress tanks with specially constructed filter presses were used.

NEW OPTICAL GLASSES

During the past few years, scientists at the American Optical Co., Southbridge, Mass., have developed, through chemical, physical, and other fundamental researches, new and improved types of glass which have now entirely replaced types of glasses formerly believed satisfactory for lenses to correct vision.

A better understanding of the composition and molecular structure of glass has made it possible to evolve glasses with greater chemical durability, better fusing properties, freedom from objectionable tints, higher light transmission, better adaptability to polishing, and improved compositions which facilitate lens-manufacturing operations.

The development of these new types of glass makes it possible for ophthalmologists, optometrists, and ophthalmic dispensors to correct defective vision with far greater accuracy and comfort than ever before.

POSTWAR DEFENSE FOR CERAMISTS
IS THE
AMERICAN CERAMIC SOCIETY

SCHOOL NOTES

PENNSYLVANIA STATE COLLEGE

Student Branch activities at the Pennsylvania State College, State College, Pa., have been under the direction of the following officers: *President*, W. Graydon Ekdahl; *Vice-President*, James L. Bachman; and *Secretary-Treasurer*, Edward Fronczak.

UNIVERSITY OF ILLINOIS

Frank W. Butterworth, president of the Western Brick Co., Danville, Ill., has been initiated as an honorary member of the University of Illinois chapter of Keramos. It is the practice of Keramos to confer this distinction from time to time on men who have made outstanding contributions to the ceramic industry. This honor is especially appropriate as Mr. Butterworth is one of the two surviving members of the Legislative Committee of the Illinois Clay Workers' Association which secured the establishment of the Department of Ceramic Engineering at the University of Illinois. Mr. Butterworth is, and has been for several years, a member of the advisory committee to the Department of Ceramic Engineering.

Recent reports show that the following recent graduates of the Department of Ceramic Engineering are stationed right in the thick of the Pacific war zone: M. E. Nelson, Pearl Harbor, Hawaii; R. R. Rucker, Schofield Barracks, Oahu, Hawaii; Joe Smith, Philippine Islands; and D. F. Lillie, Fort Anchorage, Alaska.

CERAMIC CAMERA CLUB

Fourth Annual Salon

The Fourth Annual Salon of the Ceramic Camera Club will be held April 19 to 25, 1942, in the Netherland Plaza Hotel, Cincinnati, Ohio, at the Forty-Fourth Annual Meeting of The American Ceramic Society.

Entry blanks will be mailed in the near future. Each American Ceramic Society member may exhibit six prints. All photographs (16- by 20-in. mounted) must be received in Cincinnati by April 12, 1942.

Judging will take place on Sunday afternoon, April 19. Members of the jury are as follows: Glenn Adams, president, Cincinnati Camera Club; Frederick Knoop, Cincinnati Camera Club; and Arnold Henn, Eastman Kodak Co.

Dinner Meeting

An illustrated lecture entitled "Photographic Pictorialism" will be presented by E. P. Wightman of the Eastman Kodak Co. at the dinner meeting of the Ceramic Camera Club (date to be announced later).

Publicity

Two leading camera supply companies in Cincinnati have agreed to present window displays featuring Ceramic Camera Club photographs and The American Ceramic Society. These window displays will be set up on April 5, 1942. A minimum of twelve prints is required. It is hoped that the 1940 and 1941 Salon winners will send in at least one 16- by 20-in. mounted print.

Please send them promptly to Robert W. Knauft, Charles Taylor Sons Co., 706 Burns St., Cincinnati, Ohio. Postage will be refunded at the Meeting.

MODULAR UNIT ADOPTED

AMERICAN STANDARDS ASSOCIATION PROJECT A-62

The Executive Committee of the American Standards Association Project A-62 for the Coordination of Dimensions of Building Materials and Equipment has issued a 62-page printed brochure which explains the organization of the Committee and its objectives and methods.

This Committee was organized July 13, 1939, and is sponsored by the American Institute of Architects and the Producers' Council. It is composed of more than fifty members who represent the following organizations: The American Ceramic Society, American Institute of Architects, American Institute of Steel Construction, Inc., American Iron and Steel Institute, American Society of Civil Engineers, American Society for Testing Materials, Associated General Contractors of America, Inc., Canadian Engineers' Standards Association, Cast Stone Institute, Douglas Fir Plywood Association, Federal Home Loan Bank Board, Federal Housing Administration, Public Building Administration, U. S. Housing Authority, glass block industry, Gypsum Association, Insulation Board Institute, Metal Lath Manufacturers' Association, Metal Window Institute, Modular Service Association, National Association of Building Owners and Managers, National Association of Real Estate Boards, National Bureau of Standards, National Concrete Masonry Association, National Door Manufacturers' Association, National Electrical Manufacturers' Association, National Elevator Manufacturing Industries, Inc., National Lumber Manufacturers' Association, National Mineral Wool Association, Porcelain Enamel Institute, Producers' Council, Inc., Steel Kitchen Cabinet Institute, Structural Clay Products Institute, Farm Security Administration, Forest Products Laboratory, U. S. Department of Labor, and numerous architectural schools.

The members of the Executive Committee are as follows: *Chairman*, Max H. Foley, Voorhees, Walker, Foley, & Smith, 101 Park Ave., New York, N. Y.; *Vice-Chairman*, John J. Matson, Industrial Dept., General Electric Co., Schenectady, N. Y.; *Secretary*, M. W. Adams, Executive Secretary, Modular Service Association, 110 Arlington St., Boston, Mass.; *Assistant Secretary*, H. M. Lawrence, materials engineer, American Standards Association, 29 West 39th St., New York, N. Y.; R. L. Bertin, chief engineer, White Construction Co., 95 Madison Ave., New York, N. Y.; Theodore Irving Coe, technical secretary, Dept. of Technical Services, American Institute of Architects, 1741 New York Ave., N. W., Washington, D. C.; James W. Follin, managing director, Producers' Council, Inc., 122 East 42nd St., New York, N. Y.; Frederick Heath, Jr., secretary-engineer, Colonial Clays, Inc., 311 Main St., Worcester, Mass.; Vincent B. Phelan, chief, Building Practices and Specifications, National Bureau of Standards, Washington, D. C.; and A. C. Shire, technical director, Federal Works Agency, U. S. Housing Authority, Washington, D. C.

Six working subcommittees have been appointed, viz., (1) Masonry Made of Structural Clay Products, (2) Wood Doors and Windows, (3) Masonry Made of Concrete and Cast Stone, (4) Metal Windows, (5) Natural Stones, and (6) Structural Wood.

The personnel of Subcommittee 1 on Masonry Made of Structural Clay Products is as follows: *Chairman*, Harry C. Plummer, Structural Clay Products Institute, Washington, D. C.; Henry S. Churchill, architect; Hyman Cunin, U. S. Housing Authority; Charles W. Hammett, Hammett Co., Washington, D. C.; Frederick Heath, Jr., Colonial Clays, Inc.; E. Philip Schreier, architect; and E. F. Wanner, National Fireproofing Corp.

The Committee has used a coordination principal which has been developed for masonry units largely through the pioneer studies of Frederick Heath, Jr., Colonial Clays, Inc., Worcester, Mass. A list of the publications on this subject which have appeared in the *Journal* and *Bulletin* of The American Ceramic Society is appended.

The broad principle of coordination has been studied for many years by the late Albert Farwell Bemis, with particular emphasis on structural elements of buildings other than masonry units. The heirs of Mr. Bemis have financed the nonprofit Modular Service Association which has provided the engineering service needed for the successful work of A.S.A. Committee A-62.

The brochure illustrates the use of a 4-in. increment for

sizes, details, and building layout. Brick, tile, block, sills, wood and steel windows, wood doors, and other structural elements that might be employed in a typical housing project are described.

These simple coordinated dimensions, details, and layout are being drafted as an American standard. The Committee will consider these standards early in 1942. This program, directed toward the more economical and efficient use of brick and tile as well as other stock building materials, should be studied. The brochure is made available for that purpose.

It is priced at $1.00, but it is offered free to members of The American Ceramic Society. Write to the Secretary of the Executive Committee, M. W. Adams, 110 Arlington St., Boston, Mass.

Masonry Unit Publications

(1) "Report of Preliminary Meeting on Masonry Opening Sizes," *Bull. Amer. Ceram. Soc.*, **8** [8] 263–65 (1929).

(2) "Meeting of Committee on Masonry Opening Sizes, Department of Simplified Practice," *ibid.*, [11] 345–46.

(3) Frederick T. Heath, "Masonry Failures Due to Vertical Shear," *Jour. Amer. Ceram. Soc.*, **12** [4] 230–40 (1929).

(4) Frederick T. Heath, "Standard Unit of Dimension for Masonry," *ibid.*, [10] 605–39.

(5) John Burchard, 2d, and A. F. Bemis, "Standard Unit of Dimension for Masonry" (discussion of paper No. 4), *ibid.*, **13** [8] 587–93 (1930).

(6) "Masonry Research," *Bull. Amer. Ceram. Soc.*, **9** [2] 19–21 (1930).

(7) R. C. Purdy, "Cooperation in Heavy Clay Products Industry," *ibid.*, [5] 135–39.

(8) "Inadequacy of Ceramic Product Development and Promotion," *ibid.*, **11** [11] 251–53 (1932).

(9) Frederick Heath, Jr., discussion of paper by W. D. Richardson, "Part of Brick Manufacturer in Better-Housing Program," *Bull. Amer. Ceram. Soc.*, **14** [9] 293–96 (1935); the discussion appears on pp. 296–98, same issue.

(10) Frederick Heath, Jr., "Modular Masonry," *ibid.*, **16** [1] 17–20 (1937).

(11) H. C. Plummer and Frederick Heath, Jr., "Inventory-Taking of Structural Clay Products Research Program," *ibid.*, **18** [12] 466–67 (1939).

(12) "Coordination of Dimensions of Building Materials and Equipment" (Progress Report of American Standards Association Committee A-62), *ibid.*, **19** [5] 200–201 (1940).

(13) "Progress Report of American Standards Association Sectional Committee A-62," *ibid.*, [10] 411.

NECROLOGY

LOUIS INGRAM*

Louis Ingram passed away on December 12, 1941. Mr. Ingram was chairman of the board of directors of the Ingram-Richardson Manufacturing Company of Beaver Falls, Pa., and of Frankfort, Ind., and was a founder and member of the Board of Trustees of the Porcelain Enamel Institute, Chicago, Ill.

Mr. Ingram, who died of heart failure, is survived by two sons, J. Fred Ingram, vice-president of the Ingram-Richardson Manufacturing Company and Louis Ingram, professor at Wooster College, Wooster, Ohio.

Influenced considerably by an artistic sense throughout his life, Mr. Ingram found much enjoyment in painting, piano and harp study, and in the study of nature. His furtherance of artistic stencil development in the porcelain enameling field bears evidence to this trend. His ability in music stood him in good stead when early in his career in this country he found himself playing a harp at a church to provide a livelihood.

Mr. Ingram was active in various charitable and civic work in Beaver Falls and its vicinity. He was a director of the Farmers National Bank, the local Rotary Club, president of the Beaver County Home for the Aged, director of the Beaver Valley General Hospital, the Beaver Valley Country Club, and the Manufacturers Association of Beaver County, a member of a committee of the National Association of Manufacturers, and a trustee of the College Hill Presbyterian Church.

Born in England

Mr. Ingram was born in Birmingham, England, on October 15, 1870.

For two or three generations, his ancestors had been manufacturing art and decorated glass for church windows, cathedrals, and memorial buildings. When he was a very young man, he served as an apprentice in the factories of his uncle. During this time, he also attended art schools in Birmingham and was eventually graduated.

Louis Ingram

When porcelain-enameled signs were first manufactured in England, Mr. Ingram joined the Imperial Enamel Co., Wattery Lane, Birmingham, as a designer and stencil cutter. Later on, he and Captain Baugh one of the members of the family which directed this Company, came to Ellwood City, Pa., about eight miles from Beaver Falls, to establish one of the first plants in the United States for the manufacture of porcelain-enameled signs and flat sheets. Before the plant began to operate successfully, however, some controversy developed between Captain Baugh and his associates in Ellwood City and he returned to Birmingham. The plant was not a success and the buildings intended for the enameling plant were used for other purposes.

As a result of this split-up, Mr. Ingram went from Ellwood City to New York, where he secured a position as an artist and designer with some firms which made glass signs and produced various kinds of art work.

About 1893, P. W. and S. W. Smith, who had manufactured porcelain-enameled signs near Birmingham, sold out their business in that country and came to the United States. They eventually landed in Beaver Falls and built a plant for the manufacture of porcelain-enameled signs. The Smith brothers, who knew Mr. Ingram in England,

* From *Enamelist*, **19** [3] 6–7, 44 (1941).

made arrangements to have him join them in Beaver Falls as a designer and director of their stencil-making department. The Smith brothers' organization, the Enamelled Iron Company, was in operation for approximately seven or eight years.

Shortly after the arrival of the Smith brothers in Beaver Falls, Ernest Richardson, who had had some previous enameling experience, became associated with them. He and Mr. Ingram were closely associated with each other at this Company for about eight years, until, in 1900, they organized the Ingram-Richardson Manufacturing Company at Beaver Falls, Pa., which was incorporated under the laws of Pennsylvania. In 1902, the Ingram-Richardson Manufacturing Company purchased the property of the Enamelled Iron Company and consolidated the activities of both firms, dismantling the Enamelled Iron Company and disposing of the real estate.

In 1915, the Ingram-Richardson Manufacturing Company of Indiana, Inc., was established at Frankfort, Ind. In 1924, the Ingram-Richardson Corporation was organized under the laws of New Jersey and a plant was erected at Bayonne, N. J. This plant was operated for about seven years. During the worst period of the depression, however, the Bayonne plant was closed and dismantled and the property was eventually disposed of and the firm disbanded.

In 1931, the Ingram-Richardson Investment Company was organized at Beaver Falls. Mr. Ingram and Mr. Richardson served as an Advisory Committee of the Company.

Mr. Ingram and Mr. Richardson were, throughout their long association, pioneers in the porcelain-enameled sign field and in the manufacture of (1) porcelain-enameled table tops and decorated breakfast sets, (2) porcelain-enameled steel linings for both the interior and exterior of refrigerators, (3) porcelain-enameled gas ranges and heaters, and (4) porcelain-enameled tub covers and drainboards.

NOTES FOR CERAMISTS

THIOSILICATE GLASSES

It has occurred to me that sulfur might take the position in the lattice which oxygen now occupies in common glasses and that, under suitable conditions, thiosilicate glasses would result.

Such an investigation will be undertaken by J. J. Rothermel, a graduate student in the Department of Chemistry of the University of Pittsburgh, who is working toward a Doctor of Philosophy degree.

—ALEXANDER SILVERMAN

CERAMIC ASSOCIATION OF NEW JERSEY

The Ceramic Association of New Jersey has elected the following officers for 1942:

President: H. F. KLEINFELDT, Abbé Engineering Co., New York, N. Y.
Vice-President: H. D. THROPP, Eureka Flint & Spar Co., Trenton, N. J.
Secretary-Treasurer: G. H. BROWN, Rutgers Univ., New Brunswick, N. J.
Councillor: AUGUST STAUDT, Perth Amboy Tile Works, Perth Amboy, N. J.

RADIO'S GREATEST MURAL UNVEILED JANUARY 17

A huge and colorful mural, symbolic of radio broadcasting as the universal medium of mass communication, was unveiled at the new National Broadcasting Company Building in San Francisco, Calif., on January 17, 1942.

The panel, which rises impressively above the main entrance of the broadcasting headquarters, is 40 feet high and 16 feet wide. In addition to telling the story of radio's service to the world, it provides a permanent testimonial to the genius and skill of those who conceived and created it.

Decorative tile made by Gladding, McBean & Company has been used in the mural, the first to be created for outdoor use. Colored tile, cut to fit different sections of a picture, have also been used. The design was developed by placing the 114 different colors or glazes on white 6- by 6-in. tile and firing them. By this method something has been constructed which will endure indefinitely with no fading or deterioration.

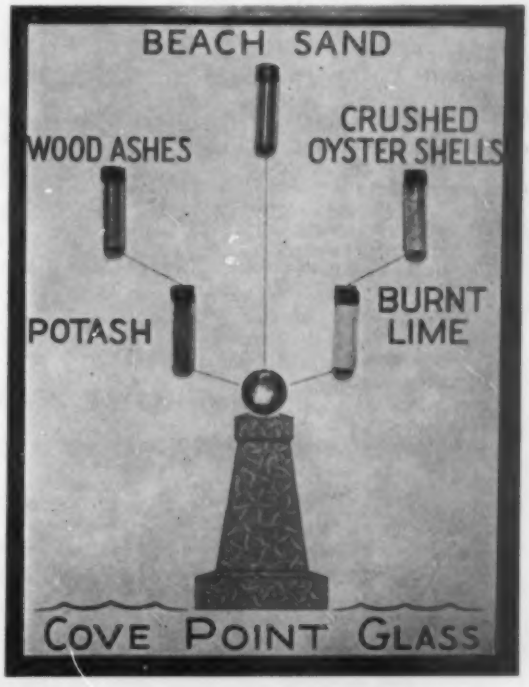
Al Nelson, assistant vice-president of NBC, makes the following comments concerning G. J. Fitzgerald, designer of the mural: "Fitzgerald's imagination has contributed a bold masterpiece. It is even more brilliant in tile than it was in either the preliminary sketches or the oil painting from which the color studies were made. You can look at the mural five minutes and get the general theme of its significance or you can study it for hours and still find new details to understand and enjoy."

COVE POINT GLASS

The unique exhibit shown in the accompanying photograph is on display in the office of Francis C. Flint, chief chemist of the Hazel-Atlas Glass Co., Washington, Pa.

The story of how Cove Point glass was "conceived, executed, and presented" is told by W. R. Lester, Maryland Glass Corp., Baltimore, Md.

"Cove Point is the summer home of Francis C. Flint and is located on the western shore of Chesapeake Bay.



Cove Point was the scene of the first two Autumn Meetings of the Glass Division of The American Ceramic Society and has also been the scene of sundry subcommittee and sub-subcommittee meetings during the past twelve years.

"In the spring of 1941, I was privileged to attend one of the meetings of the A.S.T.M. C-14 Subcommittee on Nomenclature. It was during this meeting that I was

struck with the fact that there probably had been more glass made and unmade at Cove Point than at any other place in the world, but, strange as it may seem, no one had ever seen a piece of Cove Point glass. Accordingly, the necessary raw materials were gathered from the Cove Point area. The sand was taken from the beach, oyster shells from the water, and wood ashes from the fireplace. After arriving back at my laboratory, I dried the sand, calcined the oyster shells, and extracted the potash from the wood ashes. Appropriate weights of these materials were mixed together and melted in a small fire-clay pot, and the resulting glass was cast into the form of a small lens. After annealing, an attempt was made to grind the lens to size, but, while doing so, the lens broke into pieces. Arrangements were then made with Donald E. Sharp, of the Hartford-Empire Co., Hartford, Conn., to remelt these glass pieces and to cast another lens. This was done by A. K. Lyle, of the same Company, who, upon returning the finished lens, remarked, 'Incidentally, I think you have discovered a formula for the stiffest, seediest, cordiest, *durndest* glass ever made. At 2800°F. it resembles concrete more than it does glass.'

"The finished lens and the raw materials which went into its making were mounted on a plaque, the lens being inserted in a lighthouse, said lighthouse being a small-scale model of the one situated at Cove Point. This plaque was presented to Mr. Flint, along with a suitable speech, at the last Autumn Meeting of the Glass Division held at Conneaut Lake."

CENTRAL DISTRICT ENAMELERS' CLUB

The meeting originally scheduled for February 6 will be held on March 6 at the Hotel Allerton, Cleveland, Ohio. It will be preceded by a dinner at 7:00 P.M.

IX. TESTS APPLIED TO MANUFACTURED PRODUCTS. (C) ELECTRICAL INSULATORS; (4) RADIO INSULATORS*

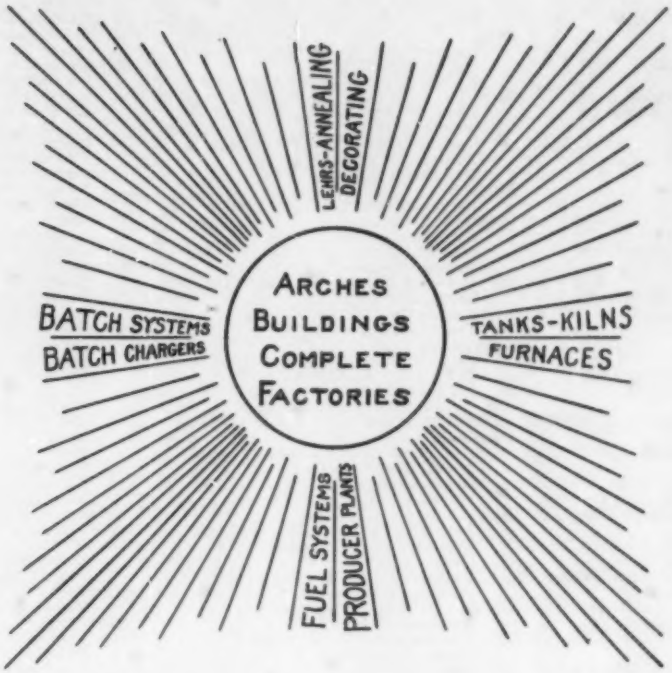
(See p. 25, this issue.)

	A.S.T.M. designation	U. S. Coast Guard specification RIS-258-A (April 21, 1941)	U. S. Navy specification RE-13A 317F (December 19, 1929)	U. S. Army specification 71-229-D (May 2, 1938)
(1) Water absorption	D116–39	A.I.E.E. insulator test No. 41, par. 41-351	Given in detail	Given in detail
(2) Dye penetration test	D116–†			
(3) Tensile strength	D116–39	For strain insulators	Required	A.S.T.M. D116–34 (specimen may also be cylinder 1.0–1.2 in. diam. x 6 in. long with metal caps cemented on)
(4) Compressive strength	"		"	
(5) Flexural strength (modulus of rupture)	"			A.S.T.M. D116–34 (test specimen may have any diam. from 0.7–1.2 in.)
(6) Bending			"	
(7) Resistance to impact (Charpy)	D256–38			
(8) Thermal shock				In detail (hot-cold water test +94° to −4°C.)
(9) Dielectric strength (commercial power frequencies usually 60 cycles)	D116–39			Given in detail: 2 in. diam. x 0.125 in. thick; 3 specimens. (Lowest value in volts per mil considered dielectric strength of material)
On test samples				
(10) Dielectric constant (11) Power factor (12) Loss factor			Loss factor (%) 300 kc.; A.S.T.M. D150–27T; specimens 4 in. diam. x 1/4 in. thick	Loss factor (%) 1 mc Specimen 6 in. diam. or 6 in. sq.; 0.1–0.2 in. thick or diam./thickness = 30/1 with diam. or side ≮ 3 in. or ⩾ 8 in. Capacitance >100 μμf. (A.S.T.M. D150–36T) or General Radio Co. type 516–B or 516–C radio-frequency bridge)
60 cycles	D150–39T			
1 kc.	"			
1 mc.	"			
(13) Wet-surface leakage test		Given in detail		
(14) Tolerances	N.E.M.A. steatite Electric Insulation Standards Pub. No. 41–63, January, 1941			

* No data are given for tests of Civil Aeronautics Authority.
† Test being worked on for inclusion in A.S.T.M. methods.

IX. TESTS APPLIED TO MANUFACTURED PRODUCTS. (C) ELECTRICAL INSULATORS; (5) RADIO CAPACITORS.

Data for Radio Capacitors are similar to data given for (4) Radio Insulators except for the following points: In tests for (10), (11), and (12), the loss factors on test samples are at 1 kc., 1 mc., and > 1 mc., respectively; test (15), temperature coefficient of capacity for range 20°–*X* °C.



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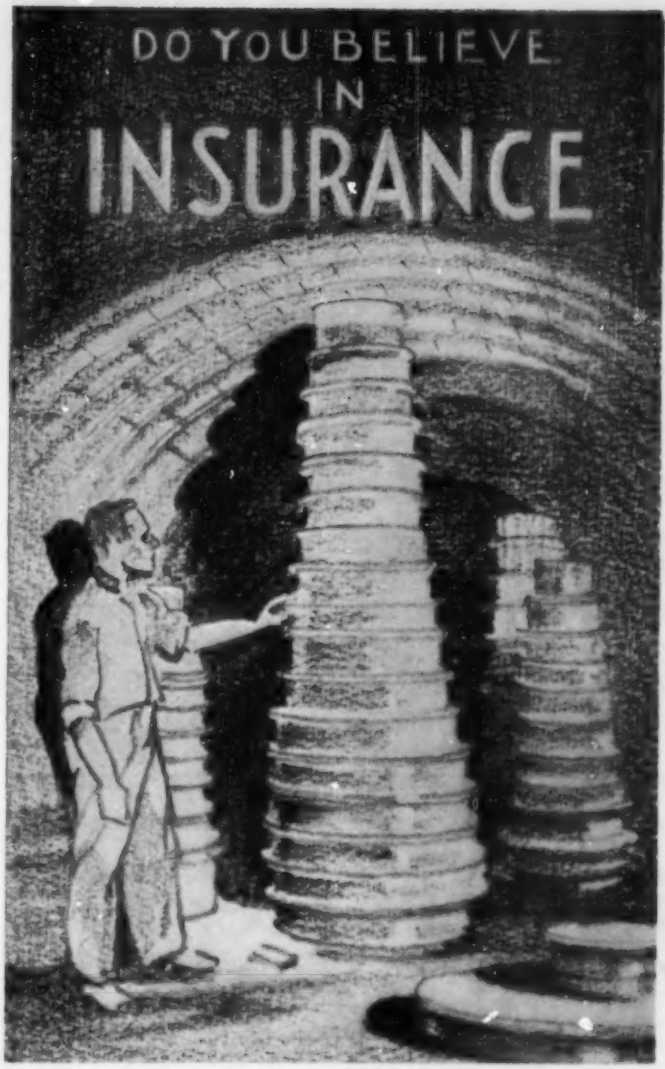

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Thomas Alabama Kaolin Co.
Titanium Alloy & Mfg. Co.
United Clay Mines Corp.
The Vitro Mfg. Co.

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Great Lakes Foundry Sand Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Potters Supply Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.

Clay (German Vallendar)
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Kentucky Clay Mining Co.
Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Clay (Micronized)
Porcelain Enamel and Mfg. Co.

Clay Miners
American Colloid Company
Great Lakes Foundry Sand Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Spinks, H. C., Clay Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.

Clay (Potters)
Denver Fire Clay Co.
Hammill & Gillespie, Inc.
The Hommel, O., Co., Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Spinks, H. C., Clay Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.

Clay (Process Equipment)
Lancaster Iron Works, Inc.
National Engineering Co.

Clay (Sagger)
Georgia Kaolin Co.
Great Lakes Foundry Sand Co.
The Hommel, O., Co., Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Potters Supply Co.
Spinks, H. C., Clay Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.

Clay-Slip (Albany)
Hammill & Gillespie, Inc.
United Clay Mines Corp.

Clay (Wad)
Kentucky Clay Mining Co.
Potters Supply Co.
Spinks, H. C., Clay Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.

Clay (Wall Tile)
Hammill & Gillespie, Inc.
Kentucky Clay Mining Co.
Maxson, Elwyn L.
Paper Makers Importing Co.
Spinks, H. C., Clay Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.

Cleaners
Pennsylvania Salt Mfg. Co.
Porcelain Enamel and Mfg. Co.

Cleaners, Chemical
Harshaw Chemical Co.
Pennsylvania Salt Mfg. Co.

Clocks (Gauge Board)
The Hommel, O., Co., Inc.

Cobalt Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Cobalt Sulphate
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.

Colors
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Cone Plaques
Industrial Ceramic Products, Inc.

Cones
The Edward Orton, Jr., Ceramic Foundation

Conveying Equipment
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
National Engineering Co.

Copper Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.

Corhart
Corhart Refractories Co.

Cornwall Stone (Imported)
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Eureka Flint & Spar Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
Pennsylvania Pulverizing Co.

Crucibles (Filter, Melting, Ignition)
Carborundum Co.
Denver Fire Clay Co.
Norton Co.
Potters Supply Co.

Crushers (Clay)
Lancaster Iron Works, Inc.

Cryolite (see Kryolith)
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Pennsylvania Salt Mfg. Co.
The Vitro Mfg. Co.

Crystolon (Refractory Products)
Norton Co.

Cullet, Washing Plants, Incinerators, Crushers
Frazier-Simplex, Inc.

Cutters (Bar)
Industrial Ceramic Products, Inc.

Decorating Supplies
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.

Disintegrators
Lancaster Iron Works, Inc.
National Engineering Co.

Dryer (Pipe Rack)
Lancaster Iron Works, Inc.

Drying Machinery
Frazier-Simplex, Inc.
Lancaster Iron Works, Inc.
Proctor & Schwartz, Inc.
F. J. Stokes Machine Company (Slip Dryers)

Electrocast Refractories
Corhart Refractories Co.

Enamelers' Borax
Porcelain Enamel and Mfg. Co.

Enameling Equipment (Complete)
Ceramic Color & Chemical Mfg. Co.
Frazier-Simplex, Inc.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
The Vitro Mfg. Co.

Enameling Furnaces
Carborundum Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Lancaster Iron Works, Inc.
Norton Co.

Enameling Iron (Sheet)
American Rolling Mill Co.

Enameling Muffles
Carborundum Co. (*Carbofrax*)
Frazier-Simplex, Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Norton Co. (*Alundum*)

Enameling (Practical Service)
Ceramic Color & Chemical Mfg. Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Metal & Thermit Corp.
Porcelain Enamel and Mfg. Co.
Titanium Alloy & Mfg. Co.
The Vitro Mfg. Co.

Enamels
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc. R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Enamel Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.

Enamels (Porcelain)
Ceramic Color & Chemical Mfg. Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Porcelain Enamel and Mfg. Co.
Titanium Alloy & Mfg. Co.
The Vitro Mfg. Co.

Equipment (Porcelain Enameling)
Ceramic Color & Chemical Mfg. Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.

Feldspar
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Eureka Flint & Spar Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
Pennsylvania Pulverizing Co.
Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.

Filter Fabrics
Metakloth Company

Fire Brick
Carborundum Co.
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Denver Fire Clay Co.
Electro Refractories & Alloys Corp.
Norton Co.

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Lancaster Iron Works, Inc.

Fire Clay
Denver Fire Clay Co.
Great Lakes Foundry Sand Co.
Spinks, H. C., Clay Co.
Thomas Alabama Kaolin Co.

Flint
Ceramic Color & Chemical Mfg. Co.
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Great Lakes Foundry Sand Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
Pennsylvania Pulverizing Co.
Porcelain Enamel and Mfg. Co.

Flint Pebbles
Ceramic Color & Chemical Mfg. Co.
Eureka Flint & Spar Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
The Vitro Mfg. Co.

Floors (Non-Slip)
Norton Co.

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Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.

French Flint
Eureka Flint & Spar Co.
Maxson, Elwyn L.
Paper Makers Importing Co.

Frit
Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Porcelain Enamel and Mfg. Co.
Titanium Alloy & Mfg. Co.
The Vitro Mfg. Co.

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Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
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Denver Fire Clay Co.
Frazier-Simplex, Inc.
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Swindell-Dressler Corp.

Furnaces, Enameling
Swindell-Dressler Corp.

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Glass Thickness Gauge
Bausch & Lomb Optical Co.
Glaze and Body Spar
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.
Glazes and Enamels
Ceramic Color & Chemical Mfg. Co.
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Porcelain Enamel and Mfg. Co.
Titanium Alloy & Mfg. Co.
The Vitro Mfg. Co.
Glaze Spar
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Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Eureka Flint & Spar Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
Goggles
The Hommel, O., Co., Inc.
Gold
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
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Norton Co. (*Crystolon*)
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Norton Co.
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Denison Engineering Co.
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Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
Iron (Enameling)
American Rolling Mill Co.
Iron Oxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Porcelain Enamel and Mfg. Co.
The Vitro Mfg. Co.
Kaolin
Ceramic Color & Chemical Mfg. Co.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Maxson, Elwyn L.
Paper Makers Importing Co.
Thomas Alabama Kaolin Co.
United Clay Mines Corp.
The Vitro Mfg. Co.
Kilns, China (Decorating)
Denver Fire Clay Co.
Drakenfeld, B. F., & Co.
Frazier-Simplex, Inc.
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Kryolith (see Cryolite)
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Ceramic Color & Chemical Mfg. Co.
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Lithium Minerals
Foote Mineral Co.
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Magnesia (Fused)
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Norton Co.
Magnesia (Sintered, Calcined)
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Magnesite
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
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Hammill & Gillespie, Inc.
Harshaw Chemical Co.
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Magnesium Carbonate
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Drakenfeld, B. F., & Co.
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.
Manganese Dioxide
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Foote Mineral Co.
Manganese (Oxide)
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Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.
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National Engineering Co.
F. J. Stokes Machine Company
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National Engineering Co.
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Mixers (Laboratory)
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National Engineering Co.
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Lancaster Iron Works, Inc.
Muffles (Furnace) (Laboratory)
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Harshaw Chemical Co.
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Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Nepheline Syenite
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Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Nitrates (Cobalt, Sodium)
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Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.
Nitre
Ceramic Color & Chemical Mfg. Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Norbide (Norton Boron Carbide)
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Olivine
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Opacifiers
Ceramic Color & Chemical Mfg. Co
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Overglaze Colors
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
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Oxides
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Drakenfeld, B. F., & Co.
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Harshaw Chemical Co.
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Porcelain Enamel and Mfg. Co.
Titanium Alloy & Mfg. Co.
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The Hommel, O., Co., Inc.
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Ingram-Richardson Mfg. Co. of Indiana, Inc.
Louthan Mfg. Co.
Potters Supply Co.
Pins (Tile Setter)
Louthan Mfg. Co.
Placing Sand
Great Lakes Foundry Sand Co.
Pennsylvania Pulverizing Co.
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- Denver Fire Clay Co.
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- Norton Co.

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- Carborundum Co.
- Corhart Refractories Co.
- Denver Fire Clay Co.
- Electro Refractories & Alloys Corp.
- Louthan Mfg. Co.
- Norton Co.
- Thomas Alabama Kaolin Co.
- Titanium Alloy & Mfg. Co.

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- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- Metal & Thermit Corp.
- The Vitro Mfg. Co.

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- Carborundum Co.
- Electro Refractories & Alloys Corp.
- Norton Co.
- Potters Supply Co.

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- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
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- Lancaster Iron Works, Inc.

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- The Hommel, O., Co., Inc.

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- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- The Hommel, O., Co., Inc.
- The Vitro Mfg. Co.

Selenium
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Foote Mineral Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- The Vitro Mfg. Co.

Setters (Tableware)
- Louthan Mfg. Co.

Sheets (Enameling Iron)
- American Rolling Mill Co.

Silica (Fused)
- Electro Refractories & Alloys Corp.
- Foote Mineral Co.
- The Hommel, O., Co., Inc.

Silicate of Soda
- Ceramic Color & Chemical Mfg. Co.
- Denver Fire Clay Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.

Silicon Carbide
- Carborundum Co.
- Electro Refractories & Alloys Corp.
- Norton Co.

Silicon Carbide Firesand
- Carborundum Co.

Sillimanite Refractories
- Denver Fire Clay Co.
- Electro Refractories & Alloys Corp.

Slab Pushers—Hydraulic
- Spencer Lens Co.

Slabs (Furnace)
- Carborundum Co.
- Electro Refractories & Alloys Corp.
- Ingram-Richardson Mfg. Co. of Indiana, Inc.
- Norton Co.

Soda Ash
- American Potash & Chemical Corp.
- Ceramic Color & Chemical Mfg. Co.
- Denver Fire Clay Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- Pennsylvania Salt Mfg. Co.
- Solvay Sales Corp.
- The Vitro Mfg. Co.

Sodium Antimonate
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- Metal & Thermit Corp.
- The Vitro Mfg. Co.

Sodium Fluoride
- Ceramic Color & Chemical Mfg. Co.
- Denver Fire Clay Co.
- Drakenfeld, B. F., & Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- The Vitro Mfg. Co.

Sodium Metasilicate
- Harshaw Chemical Co.

Sodium Nitrite
- Ceramic Color & Chemical Mfg. Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.

Sodium Silica Fluoride
- Ceramic Color & Chemical Mfg. Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.

Sodium Uranate
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.

Soot Blowers
- Frazier-Simplex, Inc.

Special Machines
- Frazier-Simplex, Inc.

Spar
- Ceramic Color & Chemical Mfg. Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Eureka Flint & Spar Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- Maxson, Elwyn L.
- Paper Makers Importing Co.
- Pennsylvania Pulverizing Co.
- The Vitro Mfg. Co.

Spray Booths
- Ceramic Color & Chemical Mfg. Co.
- The Hommel, O., Co., Inc.

Spraying Equipment
- Ceramic Color & Chemical Mfg. Co.
- The Hommel, O., Co., Inc.

Spurs
- Louthan Mfg. Co.
- Potters Supply Co.

Stacks
- Lancaster Iron Works, Inc.

Steel Plate Construction
- Lancaster Iron Works, Inc.

Stilts
- The Hommel, O., Co., Inc.
- Industrial Ceramic Products, Inc.
- Louthan Mfg. Co.
- Potters Supply Co.

Sulfuric Acid
- Denver Fire Clay Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- Pennsylvania Salt Mfg. Co.

Talc
- Ceramic Color & Chemical Mfg. Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Hammill & Gillespie, Inc.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- International Pulp Company
- Paper Makers Importing Co.

Tanks
- Frazier-Simplex, Inc.

Tank Blocks
- Corhart Refractories Co.

Tanks (Pickle)
- The Hommel, O., Co., Inc.

Tanks for Raw Material Steel or Concrete
- Lancaster Iron Works, Inc.

Tile (Floor)
- Norton Co.

Tile (Muffle)
- Carborundum Co.
- Electro Refractories & Alloys Corp.
- Norton Co.

Tile Setter Pins
- Louthan Mfg. Co.

Tile (Refractory)
- Carborundum Co. (*Carbofrax*)
- Denver Fire Clay Co.
- Electro Refractories & Alloys Corp.
- Norton Co.
- Thomas Alabama Kaolin Co.

Tile (Wall)
- Denver Fire Clay Co.
- Thomas Alabama Kaolin Co.

Tin Oxide
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- The Hommel, O., Co., Inc.
- Metal & Thermit Corp.
- The Vitro Mfg. Co.

Titanium
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Foote Mineral Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- Titanium Alloy & Mfg. Co.
- The Vitro Mfg. Co.

Titanium Oxide
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
- Foote Mineral Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.
- Metal & Thermit Corp.
- Titanium Alloy Mfg. Co.
- The Vitro Mfg. Co.

Trisodium Phosphate
- Harshaw Chemical Co.

Trucks
- Lancaster Iron Works, Inc.

Tubes (Insulating)
- Carborundum Co.
- Louthan Mfg. Co.
- McDanel Refractory Porcelain Co.
- Norton Co.

Tubes (Pyrometer)
- Carborundum Co.
- Denver Fire Clay Co.
- Electro Refractories & Alloys Corp.
- McDanel Refractory Porcelain Co.
- Montgomery Porcelain Products Co.
- Norton Co.

Uranium Oxide
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Harshaw Chemical Co.
- The Hommel, O., Co., Inc.

Uranium Oxide (Yellow-Orange-Black)
- Ceramic Color & Chemical Mfg. Co.
- Drakenfeld, B. F., & Co.
- Du Pont de Nemours, E. I., & Co., Inc. R. & H. Chemicals Dept.
- The Hommel, O., Co., Inc.
- The Vitro Mfg. Co.

Water Softening Plants
- Frazier-Simplex, Inc.

Wet Enamel
Ceramic Color & Chemical Mfg. Co.
The Hommel, O., Co., Inc.
Ingram-Richardson Mfg. Co. of Indiana, Inc.
Porcelain Enamel and Mfg. Co.
Titanium Alloy & Mfg. Co.
The Vitro Mfg. Co.

Whiting
Ceramic Color & Chemical Mfg. Co.
Drakenfeld, B. F., & Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Hammill & Gillespie, Inc.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Paper Makers Importing Co.
The Vitro Mfg. Co.

Winding Drums
Lancaster Iron Works, Inc.

Zinc Oxide
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
The Vitro Mfg. Co.

Zircon
Ceramic Color & Chemical Mfg. Co.
Foote Mineral Co.
The Hommel, O., Co., Inc.

Zirconia
Ceramic Color & Chemical Mfg. Co.
Du Pont de Nemours, E. I., & Co., Inc., R. & H. Chemicals Dept.
Foote Mineral Co.
Harshaw Chemical Co.
The Hommel, O., Co., Inc.
Metal & Thermit Corp.
Titanium Alloy & Mfg. Co.
The Vitro Mfg. Co.

Zirconium Oxide
Ceramic Color & Chemical Mfg. Co.
Foote Mineral Co.
The Hommel, O., Co., Inc.
Titanium Alloy Mfg. Co.

Zirkite (Natural ZrO_2)
Foote Mineral Co.

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Full Details Furnished on Request

At Last – A White Bentonite!

A bentonite as white as this paper for ceramic use.

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Produced by
AMERICAN COLLOID COMPANY
363 W. Superior St. Chicago, Illinois

A LABORATORY GUN *that sprays* COLOR *bullets!*

AN air-gun hisses in the hands of a Du Pont ceramic color specialist. Quickly it applies a lovely, inexpensive and lasting color to glass. It's a new shade and in the Service Laboratory it is undergoing a thorough test. Naturally, the application, firing, etc., closely duplicated the methods used in mass production of decorated glassware. A few years ago practically all inexpensive glassware was undecorated. But the public wanted color.

In cooperation with the industry, Du Pont research ceramists and chemists developed a line of low fire, high resistant glass colors. The gay, vivid hues and tints withstand acids and alkalies. And they're rapidly, economically applied by spraying, squeegee or automatic equipment.

It was no isolated, lucky "discovery" that made these beautiful resistant colors available to manufacturers. Rather it was almost endless experimentation, and tedious testing at every step—typical of the efforts of the Du Pont Ceramic Service Laboratory. Out of this research have come other important improvements: better metallic decorations, domestic photolith decals, and new glazes, lusters and other products for ceramics and glass.

If you have a problem, put it up to Du Pont's experienced technical staff. They'll do all they can to help you find practical answers.

DU PONT

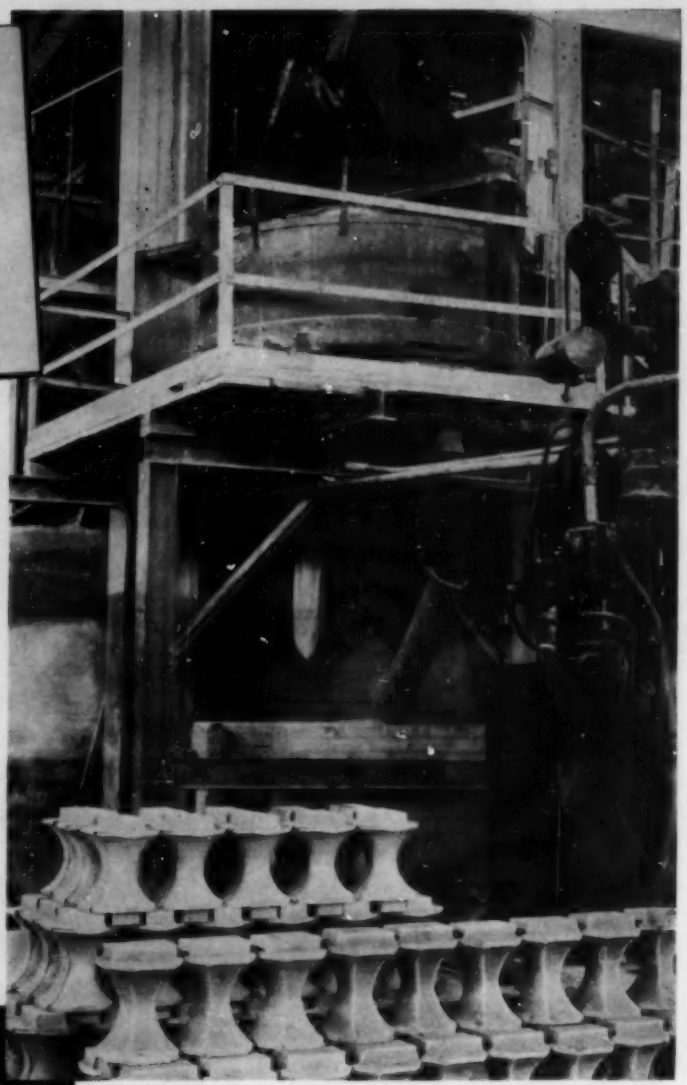
CERAMIC PRODUCTS DIVISION

E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
The R. & H. Chemicals Department
Wilmington, Delaware
District Sales Offices: Baltimore, Boston, Charlotte, Chicago, Cleveland, Kansas City, Newark, New York, Philadelphia, Pittsburgh, San Francisco

PROBLEM: Preparation of clays for Special Shapes. Must have good load bearing properties with minimum shrinkage and expansion.

SOLUTION: Install a No. 2–6 ft. dia. pan SIMPSON INTENSIVE MIXER.

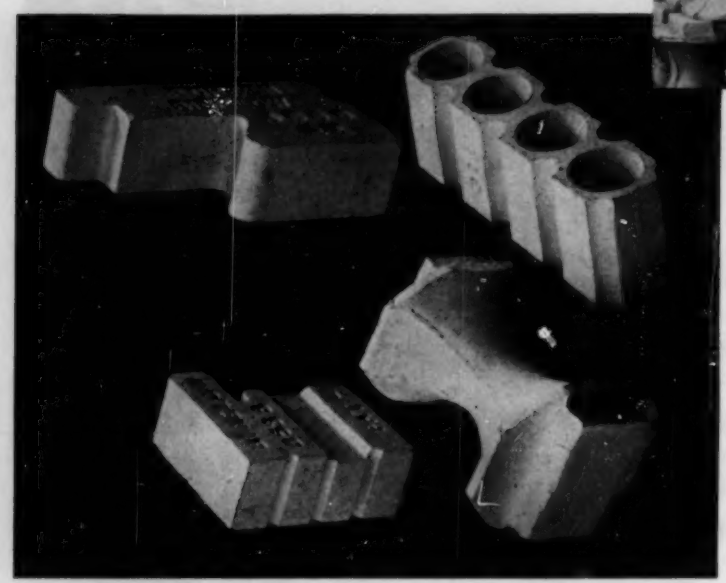
EXAMPLE: A. P. Green Fire Brick Co.



HERE'S another example of the way in which Simpson Intensive Mixers are being used successfully to obtain controlled mixing of clays for special hand-molded shapes. This time it's the A. P. Green Fire Brick Co. of Mexico, Mo.

The preparation by mulling in a No. 2—6 ft. dia. pan Simpson Mixer permits the required precise, even tempering of the clays, which are used for a wide variety of special shapes, particularly certain large tiles which must possess good load-bearing properties and which must not show excessive shrinkage or expansion.

Have you a mixing problem that entails product improvement, less waste, greater economy? Then get the facts about Simpson Intensive Mixers today!



• *Shown above is the No. 2 — 6 ft. dia. pan Simpson Intensive Mixer installation at the A. P. Green Fire Brick Co., Mexico, Mo., showing press in foreground and special checker tile for which the clay body is prepared in the Simpson Mixer. Illustrated at the left are four hand-molded special shapes from clays prepared in the mixer.*

HAVE YOU RECEIVED YOUR NEW CATALOG?

• *If you have not already sent for your copy of the new 36-page Simpson Intensive Mixer Catalog, be sure and do so today! It's free to executives and engineers who request it on their company's letterhead.*

SIMPSON INTENSIVE MIXERS

NATIONAL ENGINEERING COMPANY

MACHINERY HALL BUILDING • CHICAGO, ILLINOIS

Manufacturers and Selling Agents for Continental European Countries:—The Geo. Fletcher Steel & Iron Works, Sandhausen, Switzerland. For the British Possessions, excluding Canada and Australia—Aspdin's Limited, Halifax, England. For Canada—Dominion Engineering Co., Ltd., Montreal, Canada. For Australia and New Zealand—Gibson Battle & Co., Pty., Ltd., Sydney, Australia

H. C. SPINKS CLAY COMPANY

Miners and Shippers of

BALL, SAGGER AND WAD CLAY

NEWPORT, KY.

Los Angeles, California
February 1, 1942

Mr. Pete Potter
Comfortable Sanitary Pottery Mfg. Co.
Pottsville, U. S. A.

Dear Pete:

The West Coast is busy, of course, like all the rest of our Country, and the War Effort is everyone's main thought. The reports as to the speed with which they are producing planes and ships are wonderful. Must be making them on automatic jiggers. A good many of our friends in these plants are already in the Service.

Sincerely,

Dick Carothers

General Manager
H. C. SPINKS CLAY COMPANY

Vol. 25, No. 4, Journal, pp. 97-122

THE JOURNAL and THE BULLETIN, FEBRUARY, 19, 1945

thank m & t sodium antimonate

As thousands of ladies step into their baths each morning they don't realize that the gleaming finish of their coral (jade, peach or what-have-you) tubs is possible because of M & T Sodium Antimonate. Manufactured under close laboratory control, this opacifier has a high refractive index which assures brilliance and uniformity of color in the enamel.

As producers of Sodium Antimonate and Tin Oxide we offer the facilities of our ceramic laboratory to enamel and glaze manufacturers who may be having production troubles.

We have an entire plant devoted to the manufacture of a high quality of Oxide of Antimony. Orders filled while the supply lasts.

m TIN OXIDE & SODIUM ANTIMONATE t

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